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A STUDY OF BONE REGENERATION

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IN THE healing process of bone the new bone may be pictured as emanating from two different sources: partly from the ends of the bone fragments and partly from the connective tissue surrounding the seat of fracture. In the latter case, the connective tissue is considered transformed into bony tissue by virtue of a special process—the metaplastic theory of bone formation. In the former case, on the other hand, the callus is supposed to be manufactured from specific bone cells which are present in a pre-existing state within the different skeletal layers and which for some reason or another become stimulated into active proliferation—the specific osteoblastic theory.

In strong support of the metaplastic theory we have the fact that we are able to observe directly under the microscope how bone forms in a connective tissue medium without any morphological connection with living bone tissue. Whereas connective tissue is formed in the body in the presence of all sorts of tissue reactions, bone is formed only under special circumstances. Yet the advocates of the metaplastic school have failed to offer any explanation as to why at times connective tissue may in quite a regular fashion be transformed into bone tissue. "*Quelles sont les causes de l'évolution ostéoblastiques des fibroblastes? Personne ne nous le dit.*" (Leriche and Policard, 1934.)

Among the different skeletal strata, periosteum has of old been ascribed, as is well known, a dominating rôle in bone regeneration. Experiments showing bone formation after transplantation of isolated periosteum into soft tissues have been referred to as the chief proof of this osteogenetic power of periosteum. However, the results of these investigations do not entirely agree with one another. While some authors have found bone to be formed with fairly great regularity, others again have reported large series of experiments in which in no single case bone could be demonstrated. A review of the experience we now possess of free periosteal transplantations, clearly shows that a definite parallelism exists between the results obtained and the anatomical structure of the periosteum under different age periods. As is well known, the periosteum is made up during skeletal growth of two well differentiated layers—an inner one, the cambium layer, which faces the hard bone tissue, and an outer layer, the adventitia, which consists of ordinary connective tissue poor in cells. At the termination of skeletal growth the cambium layer disappears, and the cell deficient adventitia alone remains. All experimental investigations now show that on periosteal transplantation bone formation takes place only in animals the skeletons of which are still

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in the process of growth. No one has succeeded in getting any bone formation on grafting periosteum into soft structures alone after growth of the bony system has come to an end. Baetzner carried out a series of 57 experiments of that nature on full grown rabbits and did not obtain new bone in a single case. It is obvious that it is only the cambium layer of the growing bone that has the power to stimulate the formation of new bone. Therefore, under such circumstances it is impossible to attribute any general importance to the bone forming capacity of periosteum.

If a piece of fully differentiated, hard, living bone tissue is grafted into a medium of soft tissue, new bone always forms. It is clear, therefore, that there must be some relation between the newly formed bone and the grafted bone. Since the explanations given in the literature as to the mode of production of new bone on transplantation of hard bone tissue are contradictory I have carried out a few experiments of my own.

EXPERIMENTS WITH AUTOGENOUS GRAFTS

The animals used in these experiments were rabbits. From a piece of bone taken from the middle of the radius or ulna, the periosteum was carefully scraped away with a sharp knife and, in addition, in about half the animals a superficial layer of bone was removed by a sharp raspatory. The bone fragments—as a rule of fairly large size, measuring 1 to 1.5 centimeters in length—were implanted either subcutaneously or intramuscularly. Full grown as well as young animals were used and in all of them autoplastic grafts were used. In 20 animals the period of observation varied between 2 and 14 days; in 8, between 15 and 30 days. The chief aim with this series of animals was to study at an early stage the tissue reactions which ensue in connection with the grafting of a hard compact piece of bone freed of its periosteum.

Fig. 1. Bone graft 10 days old. *a*, Necrotic bone tissue. *b*, Haversian canals. *c*, Newly formed bone tissue. *d*, Connective tissue.

A couple of days following transplantation we found lively reaction around the graft. New vessels had formed in abundance, and around these was noted considerable proliferation of cells of mesenchymal appearance—so called vascular mesenchyme. Gradually the cells spread in a more uniform manner to create extensive patches of mesenchyme. In some places the mesenchymal cells increased in size and collected in close layers into elongated laminæ which subsequently formed into young osteoid seams. These early stages of newly formed bone tissue could be seen as early as 6 days following transplantation. Regenerated bone could be found everywhere around the graft, sometimes in small colonies around one end of the bone, at other times in more or less elongated and thick seams alongside the graft in more or less intimate contact therewith. It grew day by day so that as early as 2 or 3 weeks following transplantation as much new bone had been obtained as is, on the whole, possible to get in experiments of this nature. Occasionally a cartilaginous islet was also seen.

If we follow further the fate of the grafted compact tissue, it will be noted that the bone cells will die off fairly soon. After the fourth day the first signs of diminished vitality will be noticed. The bone design becomes ill defined and the tissue affinity to dyes becomes less marked, the nuclei become matted together into pycnotic clumps and disintegrate or disappear altogether in scattered areas. At the end of about 2 weeks all bone tissue is dead. Nowhere are there any signs of cell division. The haversian canals gradually become somewhat wider than normal but contain no living cells. At these early stages the graft retains its original form entirely and therefore the border demarcating the transition between the lifeless transplanted bone tissue and the surrounding lively cell growth can clearly be seen (Fig. 1).

Figure 2 shows how bony tissue is being formed in the mesenchymal tissue. Obviously this bone formation can take place even at a certain distance from the graft. Figure 3 shows a detail, which is very highly magnified. The mesenchymal cells can be seen to migrate from all directions toward the bone lamina just being formed—the picture in a way resembling the lines of force that are present in a magnetic field.

RESULTS WITH AUTOGENOUS GRAFTS

In bone grafting, regeneration takes place, according to the specific osteoblastic theory, from young bone cells always said to vegetate on the surface of bone or within the haversian canals. Our knowledge of the structure of the periosteum in adults proves, as already mentioned, that no young bone cells exist between the adventitia of the periosteum and the hard bone tissue. "*En réalité cette couche n'existe pas*" (Leriche and Policard). We have also seen how a superficial layer of bone can be scraped off and how despite this, new bone forms adjacent to such a bone graft. If any bone forming cells were present in the haversian canals one would reasonably expect to find proliferation of bone at this very place, and from their orifices at the surface of the bone one would expect to find the young bone growing out in a broom-like fashion. Such, however, is by no means the case. We can see how the canals within the graft are empty while new bone is being formed round about it. There are no signs to indicate that fully developed bone cells are able to multiply and to continue to grow after transplantation. It is difficult, therefore, to find any evidence in support of the suggestion that the regenerated bone might emanate from cells belonging to the graft.

The advocates of the metaplastic school ascribe to lime salts an important part in the production of new bone. According to Leriche and Policard we find that "*le transplant a fourni les matériaux calcaires. L'hote a donné la matrice conjonctive. Dans ce processus, la reprice des cels calcaires est essentielle.*" The question may arise, however, as to why lime should be of such importance in the formation of the first primitive bone since tissue calcification is of course not characteristic of bone tissue particularly. All badly nourished tissue is likely to take up lime. It is only in rare exceptions that new bone is found around ordinary calcifications in the body. If we graft a piece of bone that has been previously boiled in water, we get no formation of new bone. Lime does not dissolve on boiling, nor does its chemical composition become altered. Thus we know that the presence of lime does not necessarily lead to the formation of new bone. On the other hand, we know that bone can

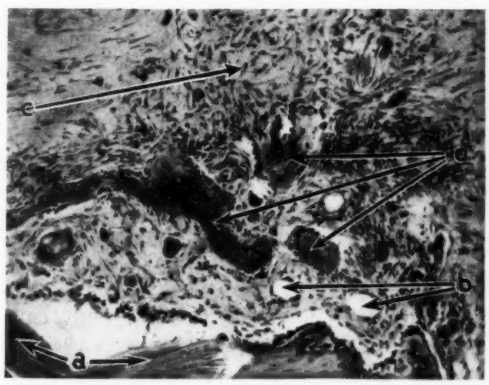

Fig. 2. Bone formation around bone graft 15 days old. *a*, Necrotic bone tissue. *b*, Vascular lumina. *c*, Mesenchymal tissue. *d*, Young bone in process of growth.

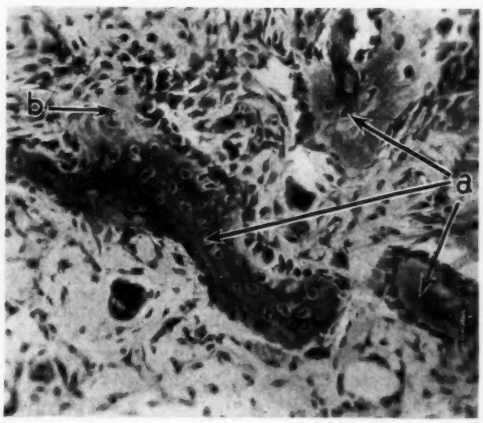

Fig. 3. *a*, Young bone laminæ. *b*, Bone in process of formation. The detail in this photomicrograph is very highly magnified.

Fig. 4. Vascular mesenchyme.

form without lime being present, as for instance in ossification of lime deficient cartilaginous tissue.

With the morphological analysis of tissue reactions in bone grafting as a basis, it would seem that another explanation of the production of new bone is called for. As already observed, new bone is formed directly out of the mesenchymal tissue which surrounds the graft. For such differentiation to take place in non-specific tissue, must necessarily show that the process is influenced in some way or another by some specific agent. Since there is every reason to believe that some connection exists between the grafted bone and the new bone tissue laid down, it is reasonable to assume that the specific stimulus needed by the mesenchymal tissue emanated from the graft itself. Therefore, it occurred to me that this stimulating agent might possibly be transferred from the graft to the surrounding areas in the form of some substance that is soluble in the tissue lymph. When the bone graft is transplanted this specifically bone forming substance is liberated from the bone tissue and is carried by the tissue lymph to the surrounding areas where it is able to activate the mesenchymal tissue in such a way that this becomes differentiated into bone tissue—either directly or by means of the embryonic pre-existing stage of bone and cartilaginous tissue.

EXPERIMENTS WITH EXTRACTS

In the hope of discovering the presence of a substance with bone-forming properties, the author carried out a few experiments for extracting this substance from bone tissue and then injecting the extract into a medium of soft tissue.

Since we have no knowledge of the chemical properties of this hypothetical substance it is naturally difficult to decide upon the most suitable solvent. In the first series of experiments aqueous extracts were used, and 10 experiments gave negative results. I then resorted to alcoholic extracts. Rabbits were used as experimental animals.

Before these experiments are attempted it is of course essential that the tissue selected for injection can be transformed into bone tissue. The injections must therefore be done in a medium containing young undifferentiated cells of mesenchymal origin. On repeated injections of 40 per cent alcohol into soft parts I found that a great abundance of mesenchymal tissue formed at the seat of injection. Figure 4 is a low power photomicrograph of such a mesenchymal field. The tissue is very rich in vessels and cells. The vessels are made up of capillaries, all of which according to the sectional direction present a rounded or more oblong appearance. The cells are either clustered together around the vascular lumina or are more sparingly scattered about in the lighter zones between the vessels. On greater magnification the grouping of the cells around the vessels can be studied (Fig. 5). At *x* the section has struck a vessel at right angles. Its lumen is bounded by 3 to 4 endothelial cells and from these concentric layers of cells of a similar appearance extend into the surrounding areas. The cells increase in size from the center to the periphery. Still farther away from the center, large cells can be seen with massive, powerfully stained nuclei. As a rule, the cells are triangular in shape with one of the borders often drawn out into a long point—a typical appearance of mesenchymal cells. The impression given by these pictures is that the fully formed mesenchymal cells ultimately emanate from the endothelial cells of the capillaries. When alcohol is used as a means

of extraction there is no need to pay attention to any special irritant for producing an ossifiable medium of soft tissue.

All the injections were made intramuscularly and everywhere auto-extracts were used. All muscles, however, are not equally well suited for the injections. Naturally such muscles should be avoided which are in widespread contact with bone since ossification is well known to occur in such muscular groups, for instance after trauma, without any exogenous irritant having been added. It is my opinion that the rectus femoris is a muscle exceedingly well adapted for these experiments. This elongated muscle passing by means of a tendon into the patella is thus in no direct contact with bone in its distal part. In its proximal part, too, it becomes attached to the pelvic parts mainly by means of tendons. On injections into the distal parts of this muscle, it can surely by taken for granted that no bone cell could become dislodged from its origin at the pelvis and be conveyed along almost the whole length of the muscle to the site of injection. Moreover, the muscle is all along surrounded by a sheath of aponeurosis. Through this capsule, as also through the surrounding powerful muscles, the rectus is well separated from the femur. It is exceedingly unlikely then that the tissue reaction taking place in this muscle could be affected in any appreciable degree by any lymph currents from the skeleton. The fact that the whole length of this narrow muscle is surrounded by a connective tissue sheath may possibly have another effect, namely, that of preventing the injected fluid from spreading over large surfaces and becoming rapidly absorbed; it is instead held back and thus the tissue reaction continues for a longer period of time.

Experiments with alcoholic extracts of bone and callus, 60 tests. As it seemed likely that some bone forming substance would be present in particularly abundant quantities as well as in an active form at the seat of fracture, experiments were first carried out with extracts from bone as well as from callus tissue. One of the forearms had been previously fractured, and amputation just above the elbow was carried out 5 to 10 days later. The soft structures of the amputated specimen

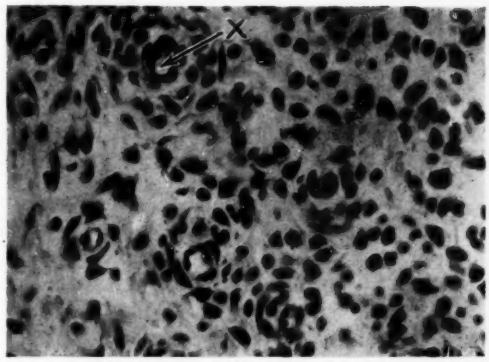

Fig. 5. Vascular mesenchyme, highly magnified.

thus obtained were removed and all bone tissue of the forearm was macerated into tiny fragments and mixed with the finely cut up callus and bone marrow into a mash which was immediately put into a tube containing 10 to 15 cubic centimeters of absolute alcohol. The extracts were kept in a thermostat at a temperature of 40 degrees C. with the view to facilitate the dissolving of the substance. The first injection was made the day after the preparation of the extract. With a fine needle 2 cubic centimeters of the supernatant portion of the clear extract was sucked up into the syringe. In some instances the absence of cells was checked by centrifugalizing the aspirated extract and by microscopic examination of the sediment. To avoid too pronounced a necrosis at the seat of injection the extract was diluted with saline solution until an alcoholic solution of about 40 per cent was obtained. Three to 5 cubic centimeters of this solution was injected into the distal end of the rectus femoris. In all 3 to 4 injections were made in each animal at intervals of, as a rule, 2 days. The period of observation varied between 2 weeks and 2 months—in most cases it extended over a period of 1½ months. At autopsy, the distal half of the rectus femoris was removed for microscopic examination. In all, 60 tests with injection of alcoholic extract were carried out. In 14 instances we found more or less extensive formation of cartilage or bone.

Figure 6 shows a preparation containing cartilaginous tissue in specimen removed 45 days after injection. The cartilage is every-

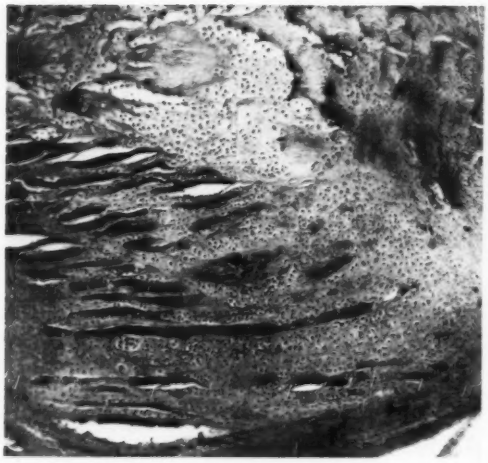

Fig. 6. Cartilaginous tissue.

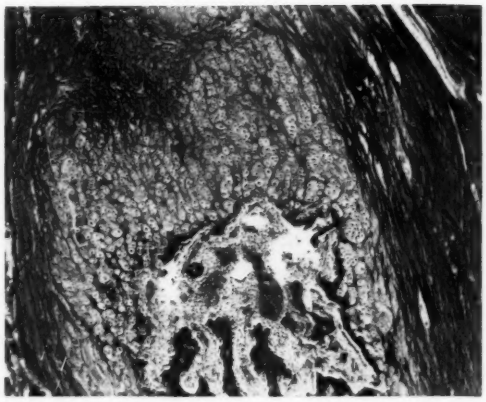

Fig. 7. Cartilage passing into spongious bone.

where of hyaline appearance. In this general view the cartilage can be seen growing in a diffuse manner infiltrating the musculature. The separated muscle fibers can be seen in more or less elongated strands with their vitality maintained. Cartilage and muscular tissue are everywhere sharply defined from one another. At the periphery the cartilage passes into cellular tissue which gradually merges into ordinary cell-deficient connective tissue. There is no capsule separating the cartilage tissue from the surrounding areas.

Figure 7 shows a preparation with a cartilage islet, the center of which is on the point of being transformed into bone tissue.

Fig. 8. Spongious bone tissue.

The specimen was obtained 60 days after injection. In those zones where the cartilage is being liquefied the cartilage cells become somewhat larger, and assume a more vesicular appearance because endoplasm increases in size at the expense of exoplasm. Numerous capillaries extend into these zones of liquefaction surrounded by mesenchymal cells. Gradually the cartilage disintegrates and becomes a tissue made up of capillaries surrounded by mesenchymal stellate cells. Young osseous laminæ are then differentiated from this vascular mesenchyma.

Figure 8 shows a piece of spongious bone tissue obtained 30 days after injection. The bone fragment is located in the musculature surrounded on both sides by a thin layer of connective tissue poor in cells. There is no cartilage in this preparation. The bone tissue has therefore been differentiated directly from the mesenchymal tissue. The nuclei are well stained and the bone structure is sharply defined, which indicates good vitality.

Experiments with alcoholic extracts of bone tissue, 10 tests. In this series the extracts were prepared from normal bone tissue. We used slightly acidified alcohol in concentrations of between 70 and 95 per cent as the extract agent. The same technique was employed as in the previous series. Since, for example, in bone grafting or in the case of fracture new bone forms at a very early stage—in fractures the formation of new bone may be observed as

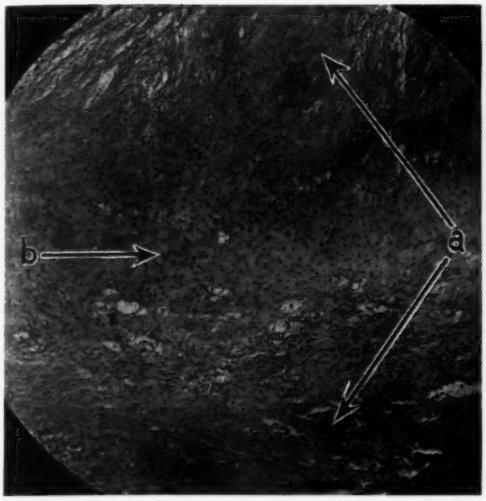

Fig. 9. Formation of cartilage. *a*, Mesenchyme. *b*, Cartilage.

early as 4 days after the fracture occurred—it was of interest to study the reaction fairly soon after the injections were made. The period of observation in these experiments was therefore a brief one—not exceeding 12 days. In 2, cartilage was obtained the appearance of which was interesting from a histogenetic point of view. These preparations were obtained as follows: May 17, amputation and preparation of extracts. The mash from the two forearms was divided into 3 parts and each part was placed in a retort containing 7 cubic centimeters of acidified 95 per cent alcoholic solution (190 cubic centimeters of absolute alcohol and 10 cubic centimeters of 0.2 per cent hydrochloric acid). The extracts were kept cold at 0 degrees C. Five cubic centimeters of a 40 per cent extract were injected on May 19, 21, and 23, respectively. The specimen was prepared on May 31 (Figs. 9, 10, and 11).

Figure 9 shows a general view of cartilaginous tissue undergoing formation. From both sides the mesenchymal tissue can be seen growing in toward the central longitudinal cartilage plate. In Figure 10 this transformation of the mesenchymal tissue into cartilage can be seen in greater magnification. In the

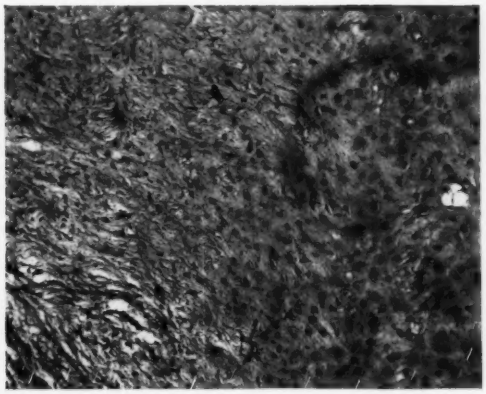

Fig. 10. Cartilage in formation, highly magnified.

original mesenchymal tissue with its stellate cells and wide interstices the mass of protoplasm is magnified around the nuclei—endoplasm—and the anastomotic outshoots become short and thick. The endoplasm assumes a granular appearance and passes into the more homogeneous so called exoplasm, of a faintly fibrillar structure. The interstices disappear and the exoplasm from the various cells becomes intimately bound up with a coherent mass of protoplasm of a clearly hyaline appearance in which the nuclei are embedded, surrounded by a lighter zone of endoplasm. Figure 11 shows a greater quantity of such fully developed cartilaginous

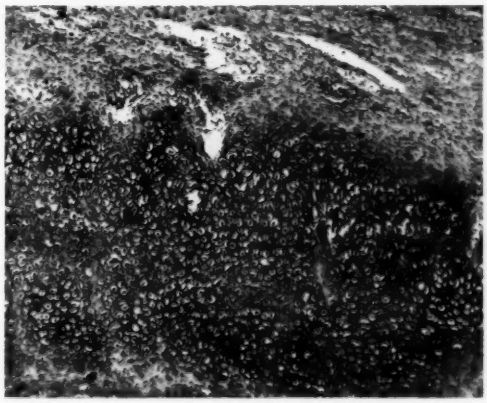

Fig. 11. Cartilage, completed.

tissue arising from a different place in the same preparation.

Controls, 80 tests. By methods identical to those employed in the preceding series of experiments, alcoholic solutions were then injected into 60 controls, the solutions being of the same concentrations and of the same quantities as in the extract tests. In 20 cases extracts of connective tissue, striated and smooth musculature were also injected by the same method. Microscopic examination disclosed in all the cases an exceedingly great abundance of newly formed connective tissue in various stages of development but never either cartilage or bone.

RESULTS IN INJECTION EXPERIMENTS

In 22 per cent of 70 animals receiving intramuscular injections of alcoholic extracts of bone and callus tissue, cartilage or bone formed. In 10, an aqueous extract of bone tissue caused the formation of no cartilage or bone at the seat of injection. In view of the extract agent employed it stands to reason that the cartilage and bone obtained cannot be the result of proliferation of living osteoblasts accompanying the injections. Moreover, the method employed would prevent osteoblasts from traveling from the periosteum of the femur to the seat of ossification in the rectus femoris. Besides, it will also be noticed that the cartilaginous tissue is directly differentiated from the mesenchymal tissue newly formed in the musculature (Fig. 10). Naturally, a process of that nature cannot take place unless aided by some specific stimulating agent that affects the initially non-specific mesenchyme. Since no new bone was formed in the controls, it is clear that this specific factor does not appear at just any kind of tissue reaction that takes place in the musculature.

I for this reason conclude that the specific stimulus, in those cases in which cartilage or bone forms, is added in the form of some substance extracted by alcohol from the skeletal tissue, a substance having the power to activate the non-specific mesenchymal tissue into the formation of bone tissue, either directly or via the embryonic primitive stage of bone, viz., cartilage.

By assuming the presence in bone tissue of a substance with bone forming properties, new bone formation in immediate connection with the skeleton can be explained. As is well known, however, bone forms in the completed organism also in sites more or less distant from the skeleton—so called heteroplastic bone formation. Naturally it would be desirable to attribute to a common principle the mode of origin of all new bone formation, no matter what its anatomical location. As is well known, bone can form in almost any organ or tissue. Usually these findings are generally regarded as rare curiosities, for example, bone formation in a nerve, in a lymph node, in the heart, the auricle, etc. Two manifestations of heteroplastic bone formation are relatively common, however; it is a common experience, for example, to find ossification in muscles after one or several injuries have been sustained. We know how such muscular ossification almost exclusively affects the muscles that are, as already mentioned, extensively connected with the skeleton. All these muscles pass at their origins or insertions directly into the bone tissue without the agency of any intervening periosteal connective tissue membrane. Lexer lays special stress on this anatomical relationship between muscle and skeleton and maintains that thereby the specific osteoblasts are able without hindrance from any membrane to wander out into the muscle, there to establish centers of ossification. As stated earlier, however, the periosteal cambium layer is absent in adults and ossification areas in muscles may be met with in all ages. In my opinion, therefore, it is more reasonable to assume in cases of trauma that some bone forming substance is liberated from the surface of the bone tissue and transferred by the tissue lymph to the surrounding musculature. In the mesenchymal tissue reactively formed around the traumatic foci of contusion in the musculature the bone forming substance encounters a suitable soil which lends itself well to being differentiated into cartilage or bone tissue.

By various experimental methods, e.g., ligation of renal vessels, we are able with great regularity to produce ossification along the different sections of the urinary tract. This

bone formation is of great interest for the reason, among others, that it is the only form of new bone we are able to produce without using material from the living skeletal tissues. For certain reasons I maintain that also in this location some specific substance causes bone formation. It is well known how a number of hormones are excreted with the urine, such as folliculin, prolan, etc. These substances have the power of activating different tissues and causing them to become differentiated in certain directions. By analogy there is every reason to assume that a bone forming substance, too, can be excreted with the urine.

In assuming that some specific bone forming substance is excreted by the kidneys, it must also be taken for granted that such a substance is present in the circulating blood, a fact which probably explains the different locations of heteroplastic bone formation. Therefore, according to this hypothesis, wherever some ossifiable medium arises in the form of young non-specific mesenchymal tissue in conjunction with some vascular lesion allowing the substance to escape from the blood stream, there is reason to expect the formation of new bone.

It is my belief that my theory permits of a uniform explanation for all the different forms of bone regeneration encountered in the adult organism. However, it would be desirable to find a certain measure of agreement between this theory of bone formation and the manner in which bone tissue is laid down during the embryonic stage of development. In conclusion, therefore, it may be of interest to refer to the recent view advanced by Spemann on the differentiation of embryonic tissues. His ingenious micro-surgical experiments of isolation and transplantation have shown how untenable is the old theory of pre-existing layers. By the re-shifting of cell material Spemann has been able to show that some of the transplanted cells are able to alter their character and develop in conformity with the conditions prevailing in their new environment. On the other hand, he found that definite regions were decisive for the development—so called organization centers. By transplanting an organizer of that nature, Spemann was further able to show how the surrounding tissue in the new medium is forced to follow the development of the organizer—a phenomenon to which he has given the name of induction. This inducive activity is considered to be caused by definite chemical substances that have the power of differentiating non-specific cell material in a certain direction. It is clear, therefore, that the most recent investigations into embryonic differentiation entirely coincide in their main principles with the view advanced by the author in this paper regarding the mode of origin of regenerated bone in the fully grown organism.

SUMMARY AND CONCLUSIONS

1. According to present theories, regeneration of bone may take place either from pre-existing cells belonging to the different skeletal layers—the specific osteoblastic theory—or as a result of transformation of non-specific connective tissue—the metaplastic theory.

2. The metaplastic theory advances no reason for the transformation of connective tissue into bone tissue.

3. According to the specific osteoblastic theory, periosteum plays a dominating part in the regeneration of bone. Experimental experience, however, has shown that it is only the periosteum of the growing skeleton that has the power to stimulate the formation of bone. On the other hand, when fully differentiated hard bone tissue is grafted, new bone is always formed.

4. In a series of experiments the author has studied more closely the mode of origin of new bone after transplanting into soft parts hard bone tissue stripped of periosteum. Morphological analysis of the tissue reactions in these experiments shows that new bone tissue is formed from the mesenchymal tissue in the areas surrounding the graft. The specific stimulus necessary for the formation of new bone is brought to the mesenchyme, according to the author's opinion, in the form of a substance liberated from the graft and conveyed with the lymph into the surrounding areas.

5. In a second series of tests the author experimented with bone tissue extracts injected into soft structures. With the use of alcoholic extracts he found in 22 per cent of 70

animals the formation of cartilage or bone at the seat of injection. In a series of 80 controls with injections of alcohol alone or alcoholic extracts of other tissues there was no formation of cartilage or bone.

6. On the basis of these experiments the author holds that bone regeneration takes place as the result of some specific bone forming substance activating the non-specific mesenchymal tissue. According to this theory the mode of origin of heteroplastic bone formation is also afforded a likely explanation. The theory also agrees with the views advanced by Spemann with regard to the embryonic development.

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THE MODE OF INCEPTION AND LATERAL SPREAD OF CERTAIN SQUAMOUS CELL CARCINOMAS

A Histopathologic and Experimental Study

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MICROSCOPIC study of small and early squamous cell carcinomas and of the so called precancerous lesions of the skin and buccopharyngeal mucosa reveals that the processes involve a segment of the epithelium and that they are not the result of changes arising in one cell or a small nidus of cells (Fig. 1). At the margins of such lesions are zones of direct continuity between normal and abnormal epithelium, and in such zones it is not possible by present staining methods to distinguish which cells are normal and which are neoplastic. Thus, such types of carcinoma appear to be segmental in origin. The appearance, in some of the well established carcinomas, of long adjacent parallel columns of cells proliferating downward from a rather thin superficial segment also affords evidence of a segmental origin of the lesion (Fig. 2).

Microscopic examination of the margins of a well established carcinoma may reveal one of several conditions. (1) A zone of direct continuity between malignant and normal epithelium with, in some instances, an interposed zone of hyperplasia (Fig. 3). (2) A distinct break between normal and malignant epithelium with the former pushed upward by infiltration of carcinoma beneath it (Fig. 4). (3) A raised rolled border of normal epithelium with a zone of direct continuity on its inner (toward the carcinoma) aspect (Fig. 5). (4) A "break" at the periphery of the lesion with cells streaming downward from the very margin of the normal epithelium, cells which appear to be undergoing carcinomatous degeneration and the change of which into carcinoma apparently contributes to the adjacent process (Fig. 6). (5) A zone of continuity between malignant and non-malignant epithelium but in which the morphologic difference between cancerous and normal cells can readily be appreciated. If multiple sections are made in different vertical planes of a given lesion, any or all of the above conditions may obtain in various segments of the margin.

Of special interest is the finding of the zones of continuity between cancerous and noncancerous epithelium at the margins of the lesions which from the clinical history began as small processes and increased in size. If the lateral spread of such lesions were due to infiltration of the malignant epithelium into the surrounding normal epithelium it should be readily appreciated on microscopic study. Small masses of malignant cells could be seen burrowing between the normal cells affording a picture quite similar to that seen in Paget's carcinoma of the nipple. Furthermore, when a carcinoma other than of cutaneous origin involves the skin there is no difficulty in distinguishing the small masses of cancer cells in the layer of squamous epithelium, pushing apart the normal cells of the latter (Fig. 7).

It would appear that the zones of continuity referred to above in the well established skin or mucosal carcinomas are best explained by the hypothesis of progressive cancerization of the normal epithelium at the margins of the initially altered segment, i.e., the cancer at its inception. When a break in the continuity of malignant and non-malignant epithelium is present, it might be assumed that the lateral spread was due entirely to centrifugal pressure of the growth, the result of multiplication of its cells, and that such growth was too rapid to permit of the opportunity of peripheral can-

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Paper presented before the Chicago Surgical Society, March 4, 1938.

Fig. 1. Photomicrograph of precancerous lesion of skin. Note that the initial changes occur over a segment of epithelium. *Z*, Zones of direct continuity with normal epithelium at margins of lesion where accurate differentiation of cells of lesion and normal cells can not be made. ×6.

cerization or that the normal epithelium about a small lesion at its inception was highly resistant to cancerous degeneration.

This hypothesis of progressive cancerization as a factor in lateral spread of such lesions is of course not a new one, but does not seem to have received much emphasis in the literature. Ribbert in his classical treatise on human carcinoma admitted the morphologic evidence for the hypothesis but rejected it as highly improbable. More recently Ewing in his text says, "Carcinomas arising from misplaced and embryonic cells are isolated from their inception, probably remain so throughout their history and illustrate in the purest form the principle that tumors grow from their own resources and not by progressive transformation of normal into tumor cells. Equally important with this principle so strongly urged by Ribbert, is the fact that many carcinomas during the period of their inception and for some portion of their early growth involve increasing areas of glands or mucous surfaces in their points of origin and thus extend in part by gradual transformation of previously normal cells."

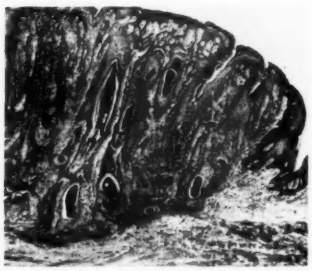


Fig. 2. Photomicrograph of squamous cell carcinoma of skin showing downgrowth of epithelial cell masses (like stalactite) from superficial layer of epithelium—further histologic evidence of segmental origin of such lesions. ×9.

In our experiments presented below, squamous cell carcinomas were induced in 60 to 90 days on the backs of white mice by triweekly applications of a 0.3 per cent methylcholanthrene solution in benzene.

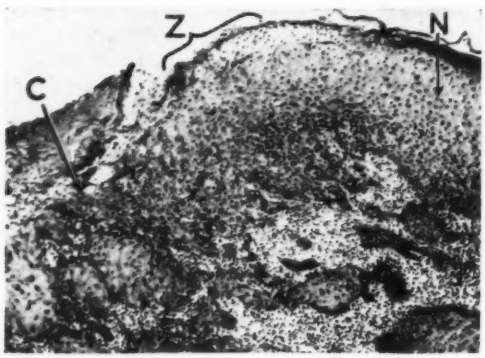


Fig. 3. Photomicrograph through margin of squamous cell carcinoma showing *Z*, zone of continuity between, *C*, cancerous and, *N*, normal epithelium. In this zone of continuity it is not possible to differentiate carcinomatous and non-carcinomatous cells. ×43.

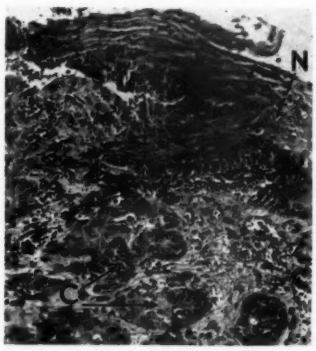


Fig. 4. Photomicrograph of a specimen showing the margin of a squamous cell carcinoma where there is a distinct break between the non-neoplastic epithelium, *N*, and the carcinoma, *C*, which is infiltrating beneath the former. ×105.

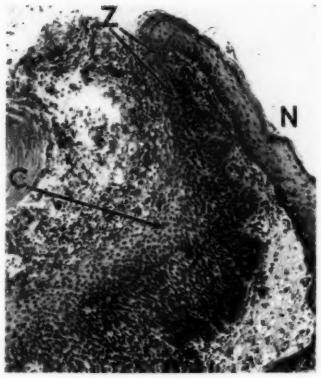


Fig. 5. Photomicrograph showing "raised rolled border" of squamous cell carcinoma. *N*, Normal epithelium. *C*, Carcinoma. Zone of continuity, *Z*, between the two in which malignant and non-malignant cells are not distinguished, one from the other. ×85.

Multiple discrete lesions appeared in the treated areas. At first they were small sessile warts, which increased in size, ulcerated in the centers, and later acquired a typical gross appearance of squamous cell carcinoma. Microscopic study of the small lesions revealed an appearance similar to that of the small precancerous and cancerous lesions in man—a definite segmental origin was readily apparent (Fig. 8). Microscopic study of the margins of the larger growths showed the same variety of conditions as seen in the human lesions, i.e., zones of continuity in which normal and neoplastic cells cannot be differentiated, areas in which there was a definite break between the normal and neoplastic epithelium, etc.

Experiment 1 (Fig. 9). A well defined early lesion was chosen from among several on the backs of each animal. By means of a hypodermic needle gauge 27 India ink dots were tattooed in a circle through the normal skin into the subcutaneous tissues about the lesion approximately 1 millimeter or more from its edges and the diameter of the circle was noted. Application of the carcinogenic substance was discontinued and the lesions were inspected daily. Of a larger series 14 animals were suitable for consideration. In 6 the lesions appeared to become stationary, or regress completely following the tattooing while other surrounding lesions continued to grow. In 2 the lesions continued to increase in size, infiltrating beneath the tattooed dots and compressing these outward so that they had the appearance of radiating spokes over the margins of the growth. Microscopic examination revealed a definite break between the

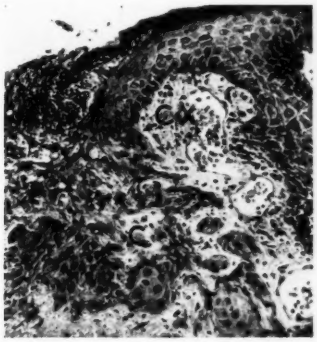


Fig. 6. Photomicrograph showing margin of squamous cell carcinoma where cells from the edge of the receding normal epithelium appear to be undergoing carcinomatous degeneration, *CX*, and streaming downward into the lesion, *C*, appear to contribute to it. ×100.

normal and neoplastic epithelium at the margins of the growth—the latter appearing to have spread laterally and by centrifugal pressure, pushing the edges of normal epithelium outward and undermining them (Fig. 10). In 6 instances the lesions overgrew the circle of dots that was in the subcutaneous tissue so that the latter were hardly or not at all visible due to the thickness of the lesion over them. At necropsy when the skin and subcutaneous tissues were reflected the circle of dots was again noted from beneath and the diameter observed to be the same as previously, i.e., the expanding carcinoma did not push the dots outward but grew *over* them (Fig. 11).

Microscopic examination of the borders of these lesions revealed in some planes a zone of direct continuity between neoplastic and non-neoplastic

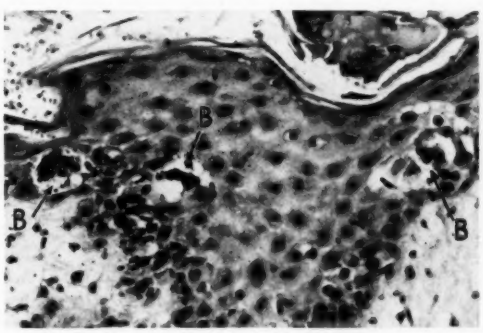


Fig. 7. Photomicrograph showing infiltration of squamous epithelium of skin by cords of breast carcinoma cells, *B*. Such a picture is not seen in normal epithelium about squamous cell carcinomas of the skin or buccopharyngeal mucosa. It would thus appear that such type of lateral spread in these lesions does not occur. ×180.

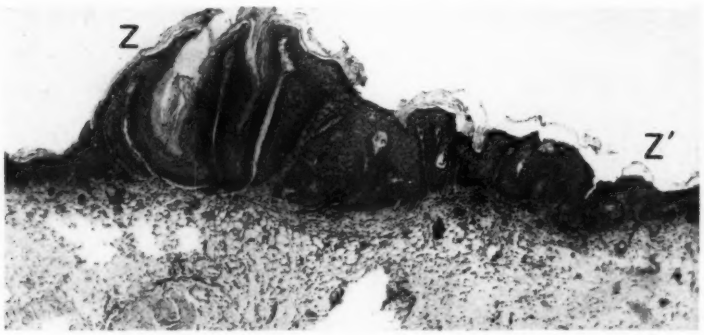
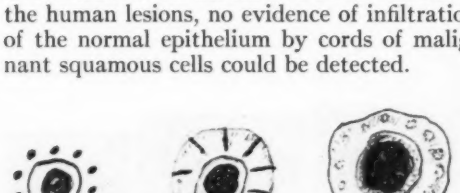


Fig. 8. Photomicrograph of beginning squamous cell carcinoma of skin of mouse's back produced by application of methylcholanthrene. Note segmental origin of lesion with zones of direct continuity between cancerous and non-neoplastic epithelium, *Z* and *Z'*. ×26.

epithelium where a differentiation of neoplastic and non-neoplastic cells was not possible. Such zones were situated directly over or beyond (outward) the ink spots which at the time of insertion were made through normal overlying skin. In 1 case one margin showed a break in continuity while at the opposite margin the receding edge of normal epithelium appeared to be the site of origin of cords of cells which were streaming downward to become continuous with the masses of frankly malignant cells infiltrating the subjacent connective tissue.

In the cases described in the preceding paragraph the lateral shift of a zone of direct continuity from within the circle of dots to a position over or outside this circle appears best explained in our opinion by the hypothesis of progressive cancerization of normal epithelium as a factor contributing to the lateral spread of the lesions. As mentioned in discussion of the human lesions, no evidence of infiltration of the normal epithelium by cords of malignant squamous cells could be detected.

If it is assumed that such progressive cancerization occurs at the periphery of the lesion it must likewise be assumed that this normal epithelium possesses a certain degree of susceptibility to malignant degeneration under influence of, among other things, factors identified with the already developed carcinoma. The fact that when a large skin surface is exposed to a carcinogenic agent the lesions are multiple, scattered, and discrete, indicates that in such surfaces there are regions of hypersusceptibility to carcinomatous degeneration surrounded by or alternating with regions which are less sensitive to such changes. When application of the carcinogenic compound has been made for some time and the multiple lesions have for the most part be-



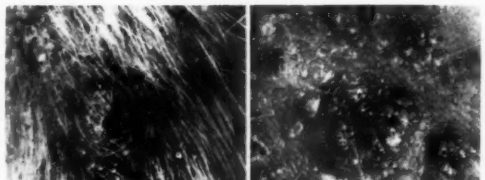


Fig. 9. Diagrammatic representation of Experiment 1, see text. A, Small carcinoma about which a circle of dots has been tattooed. B, When the carcinoma grows entirely by expansion the tattooed dots are compressed outward. C, When the lateral spread of the lesion has presumably been by cancerization of surrounding normal epithelium, the dots are obscured by thickness of the lesion over them; they have not been compressed laterally. D, Small carcinoma on mouse's back about which a circle of India ink dots has been tattooed. E, Same lesion after 14 days have elapsed. The carcinoma has spread laterally to grow *over* the circle of dots, the latter being in the subcutaneous tissues. New lesions have made their appearance in the surrounding skin.

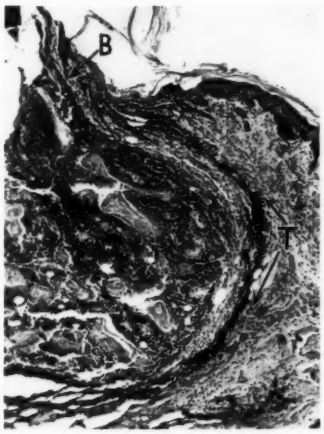


Fig. 10. Photomicrograph through experimental carcinoma on back of mouse which grew laterally as indicated in 9, B, by proliferation of its cells and centrifugal pressure. There is a break between carcinomatous and normal epithelium, *B*. The dark curved zone, *T*, consists of the tattooed dot (India ink particles in macrophages) pushed laterally and compressed by expansile growth of the lesion.

come well established and spreading carcinomas, those regions of the skin which have not developed lesions may be regarded as highly resistant to such changes. Thus it may be argued that if such a segment of resistant epithelium were apposed to a carcinoma and that even though it healed by continuity with the lesion, extension of the carcinomatous process to involve the epithelium of such a segment should not occur. Experiments along these lines were conducted as follows:

Experiment 2 (Fig. 13). Well developed carcinomas were bisected and one-half of them together with an adjacent portion of normal skin removed. The wounds thus created were sutured by interrupted fine silk. One edge of them consisted of a freshened carcinoma, the other a freshened non-neoplastic skin. After a few days when healing was apparent a line of India ink dots was tattooed about 1 to 2 millimeters from the wound margin in the normal skin in order to serve as a marker for evidence of extension into the skin of carcinoma from the opposite edge.

In 3 cases complete healing did not occur; the wounds spread leaving a granulating base. The carcinomatous edge did not appear to proliferate over this ulcer nor did normal epithelium from the opposite edge after periods of 10, 12, and 38 days, respectively, after the wound separated. In 4 cases the remaining half of the carcinoma regressed during

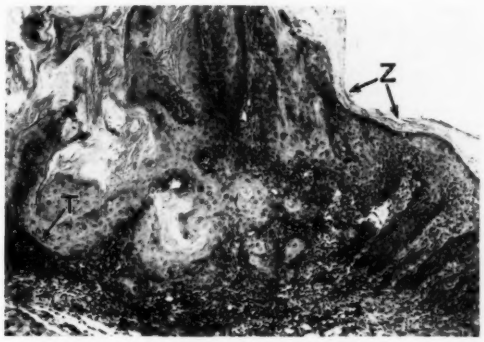


Fig. 11. Photomicrograph of margin of experimental carcinoma on mouse's back which spread laterally as indicated in Fig. 9, C. *Z*, Zone of continuity between lesion and surrounding hyperplastic epithelium in which malignant and non-malignant cells cannot be differentiated. *T*, Tattooed dot which was inserted through normal skin overlying it at the time. In its lateral spread, a contributing factor was progressive cancerization of normal epithelium. This picture corresponds fairly closely to that seen in certain human lesions as shown in Figure 3. ×63.

periods of 7, 10, 27, and 29 days, respectively, leaving healed, normal appearing surfaces. In 7 cases healing of the wounds appeared *per primam* and the carcinomas continued to spread laterally away from the sutured line. The edge at the sutured line, however, became a typical "raised rolled edge" and the lesion did not appear to be able to extend across it to involve the newly apposed skin but seemed to be halted at the healed sutured line, while infiltration of the cancer into the subepithelial connective tissue did occur (producing the pronounced "raised rolled edge" mentioned). This last series of animals died or were killed 16, 16, 23, 25, 26, 26, and 27 days, respectively, after operation, and microscopic sec-

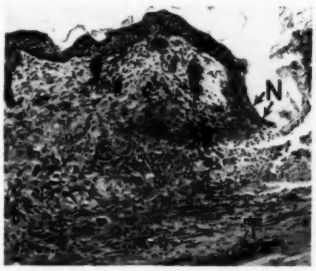


Fig. 12. Photomicrograph through margin of experimental carcinoma which spread laterally as shown in Fig. 9, C. *T*, Tattooed dot which at time of insertion was made through normal skin. The receding margin of non-neoplastic epithelium, *N*, appears to be giving rise to carcinoma cells which stream downward to contribute to the lesion, *C*. This picture corresponds closely to that seen in certain human lesions as shown in Figure 6. ×68.

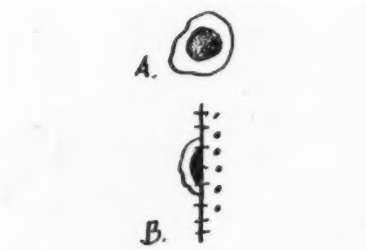


Fig. 13. Diagrammatic representation of Experiment 2. Carcinoma, A, was bisected and non-neoplastic skin sutured to it. A row of dots was tattooed along the wound margin in the apposed flap, B. In some cases the lesion grew away from the wound; the latter healed but the lesion did not cross the wound line, C. In other cases the wound healed but the carcinoma partially or completely regressed, D. In still other instances wounds separated leaving chronic ulcers over which neither neoplastic or non-neoplastic epithelium spread, E.

tions were made in several planes in right angles to the old healed wound. Microscopic study (Figs. 14 and 15) revealed that in every instance healing of the apposed normal epithelium to carcinoma had occurred resulting in a zone of direct continuity between the two. There was no visible mechanical barrier to oppose extension of the malignant epithelium into the apposed flap epithelium, yet as stated it did not occur. Infiltration in the subcutaneous tissue of the apposed edge of normal skin by a centrifugal extension of the mass of cancer cells did, on the other hand, occur, as could readily be appreciated by the general appearance of the sections and the relationship of the malignant cell masses to the tattooed dots. Microscopic study of the border of the carcinomas which lay away from the sutured wound showed extension by progressive cancerization. This contrast of the two edges of the carcinoma, one in which the adjacent skin appears to be contributing to lateral spread of the lesion by its own progressive cancerization and the other in which the adjacent normal epithelium is not involved at all and in which what little lateral spread occurs is entirely due to centrifugal pressure and subcutaneous infiltration of the cancer cell masses, is quite striking.

Fig. 15. Photomicrograph of healed wound produced according to experiment as shown in Figure 13, C, 25 days after suture. *T*, Tattooed dot made in normal skin flap. *Z*, Zone of continuity between normal skin, *N*, and carcinoma, *C*. The latter tends to infiltrate the subcutaneous tissues of the flap but does not involve the skin of the flap, although it has healed by direct continuity with it. ×39.

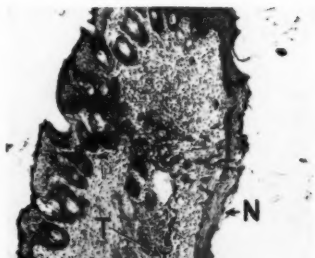


Fig. 14. Photomicrograph of healed wound (26 days) made by suturing bisected carcinoma to normal skin flap. *T*, Tattooed dot placed through normal skin. *Z*, Zone of continuity between carcinoma, *C*, and normal skin, *N*. The carcinoma did not extend to involve epithelium of flap although the opposite margin extended several millimeters away from the wound as shown in Figure 13, C. ×55.

The above findings are interpreted to indicate that since the flap of normal skin had been exposed to the carcinogenic substance as well as other regions of the back and did not develop a lesion it was highly resistant to cancerous degeneration and that when apposed to an already existing cancer, and even though it healed by continuity with the malignant epithelium, it was not converted into cancer

because of its natural high resistance to such a change.

Skin or buccopharyngeal carcinomas are observed in man which seem to arise from a limited segment of epithelium. Sections through the margins of these growths reveal the zones of continuity as described. However, the principle growth of the lesion appears to take the form of a downward proliferation and a lateral proliferation beneath the surrounding normal skin elevating the latter to form a raised rolled border. The latter experiment performed above would suggest that in such cases the surrounding epithelium is highly resistant to cancerous degeneration and the small zone of junction between normal and malignant epithelium is a relatively fixed point. The latter feature is apparently well illustrated where this junctional zone appears to have been carried outward and under a rolled raised margin due to sheer centrifugal force exerted by an expanding lesion (Fig. 16).

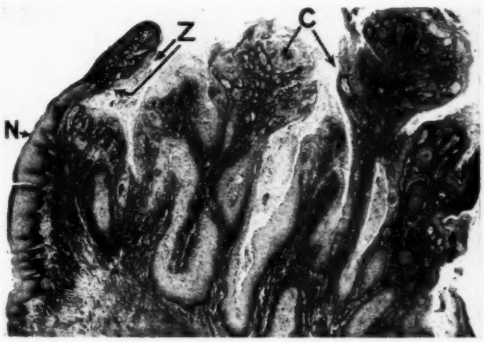


Fig. 16. Photomicrograph of squamous cell carcinoma of ear (human). *C*, Carcinoma. *N*, Hyperplastic skin. *Z*, Zone of continuity between non-neoplastic skin and carcinomatous epithelium. Detailed explanation in text. ×11.

EVALUATION OF STUDY

Little can be said about the nature of the factors which might induce progressive cancerization at the periphery of an established carcinoma, but they would appear to be identified with the already established lesion or they might well be the continued operation of the factors which led to formation of the initial lesion.

What has been said in the preceding paragraph applies, as stated, to studies made upon cutaneous and buccopharyngeal carcinoma. No studies were made upon carcinomas that arise in the mucosa of the stomach and the bowel, etc.

The statements made also cannot be applied to squamous cell carcinoma of the cervix since malignant tumors in this small region afford a special biologic problem of their own.

In conclusion, attention may be called to the apparent high degree of fragility of the experimental carcinoma to mechanical injury since an appreciable number of the lesions partially or completely regressed after the procedures outlined were carried out. The reason for this is not clear, and whether such regressions might be explained on the basis of local mobilization of macrophages as a result of the trauma cannot be gone into here. Certainly comparable human lesions at least do not exhibit such a high incidence of fragility. On the other hand, the clinical cures occasionally observed following what would be regarded as inadequate local excision or cauterization suggest that some of them might be quite susceptible to trauma.

SUMMARY

1. The hypothesis of progressive cancerization of normal epithelium in the immediate periphery of certain squamous cell carcinomas as a factor (in addition to centrifugal expansion of the lesion because of multiplication of its cells) in the continued lateral spread of such lesions is studied experimentally for the first time. Histologic comparisons with human carcinomas are made. The results are interpreted by the authors as furnishing additional support for this hypothesis.

2. An incidental observation upon the squamous cell carcinomas experimentally induced by methylcholanthrene in mice is the high incidence of marked fragility to mechanical trauma directed to the lesion or to its immediate vicinity.

NEURITIS OF THE BRACHIAL PLEXUS MECHANICAL IN ORIGIN

The Scalenus Syndrome

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THE scalenus syndrome is assuming progressively greater importance in the diagnosis of pain in the upper extremity. The present study is a review of the cases of 18 patients operated on in this clinic during the past 9 years, for complaints suggestive of cervical rib. On x-ray examination, however, these patients had either no evidence at all of cervical rib, or no more than a small outgrowth which of itself was too insignificant to account for the symptoms, or even to require removal at operation. For this group we have applied the term "scalenus syndrome."

In 1903, Bramwell attributed symptoms in such patients to pressure caused by a normal first dorsal rib. Murphy, in 1906, first drew attention to the anterior scalenus muscle as a factor in the production of symptoms arising from cervical rib. He showed that the cervical rib, in carrying the brachial plexus and subclavian artery forward, pressed these structures against the anterior scalenus muscle, and he advanced the idea that this muscle was essential to the production of symptoms.

In 1913, Morley described a case and added supraclavicular tenderness to the list of signs. Two years later, Outland and Clendening reported a similar case but made no significant comments. In 1919, Stopford and Telford reviewed 10 cases and observed that the loss of protopathic sensation was greater than that of epicritic sensation, as had been noted by Charcot in 1892. In treatment, Stopford and Telford removed part of the first rib and divided the anterior scalenus muscle incompletely, with entirely satisfactory results. In the following year Wheeler reported 2 cases treated successfully by resection of the first rib. In 1921, Bramwell and Dykes published a study of 23 patients with the clinical picture of cervical rib. At least 6, however, had no such supernumerary rib. Tenderness usually was present over the seventh cervical transverse process.

Brickner and Milch reviewed the literature in 1925, and added 1 case. They found references to the condition by Hvoslef, Szawicki, and Clerc. Hvoslef thought that there was an abnormal connection between the first and second ribs in his patient. Szawicki had 1 case. Clerc observed an abnormal scalenus medius muscle in his patient. The following year, Henry and Handousa recorded the case of a young patient who suffered "gangrene of the fingers" of the left hand while sleeping on the left side. The pulse was absent in the arm, but returned 30 seconds after the arm was elevated. No cervical rib was present.

In 1927, Adson and Coffey pointed out that, since the scalenus anticus muscle played an essential rôle in the compression of the brachial plexus and subclavian artery against the cervical rib, simple section of this muscle should effect a cure. To prove this, they reported on a series of patients who had been so treated with results as satisfactory as those formerly obtained by the more extensive operation of removing the rib. In a second article, Brickner added 6 cases and stressed the fact that, in the operative treatment, the anterior scalenus muscle should be sectioned in order to remove all pressure from the brachial plexus. Stiles, in 1929, advised section of the lower end of the scalenus medius muscle and the anterior portion of the first rib. Puusepp, reporting a case in 1931, considered the point of compression of the brachial plexus to be in the "costo-interscalene trigone," formed by the first rib, and

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scalenus anterior and scalenus medius muscles. His patient had an ipsolateral Horner's syndrome. For treatment, he advised section of the anterior scalenus muscle. In 1935, Ochsner reported 6 cases of scalenus syndrome of the type in which we have been especially interested. The following year, Wartenberg covered most of the German literature bearing on the subject. He included the scalenus syndrome in the large group of factors responsible for "brachialgia statica paraesthetica" and quoted Gaupp who, in 1894, said that there might be some angulation of the brachial plexus between the clavicle and the first rib. Braus suggested, in 1921, the possibility of compression between these two structures. In 1936 also, Flothow recorded 2 cases in which cervical ribs were present and 2 in which they were not, although all the patients had the same symptoms. In the 2 without cervical rib, section of the anterior scalenus muscle resulted in complete relief. In 1937, Craig and Knepper reviewed 6 cases of the scalenus syndrome and, in the same year, Henschen and Heusser reported 2 cases and discussed the operative treatment.

In the literature to date are the reports of 51 patients who had symptoms of cervical rib, but in whom this anomaly was not found.

Many persons with cervical ribs are free from symptoms until some time in adult life, and many carry these anomalies throughout life without symptoms. These accessory ribs vary greatly in size and in length. When they spring from the seventh cervical vertebra and are of sufficient length—5 centimeters or more—they pass forward beneath the lower cord of the brachial plexus and the subclavian artery. When ribs of this size are present, it has been our experience that simple section of the scalenus anticus will not suffice to relieve all of these patients of their symptoms, but that resection of the rib is also necessary. It has become apparent that, in the patients with symptoms from large cervical ribs and in those included as presenting the scalenus syndrome, similar factors may be concerned in the appearance of symptoms. All of them contribute to the mechanism that eventually causes undue pressure on the brachial plexus. Among them are points of embryological, anatomical, developmental, and occupational interest.

In the embryo, the arm-bud appears with its axis of growth at the level of the seventh cervical segment, but several segments are included. In time, the longitudinal growth exceeds the transverse growth of the bud, so that the nerves which pass into it tend to converge from above and below. It has long been known that some variation in the position of the limb-buds relative to the body segments occurs. A prefixed plexus is one with a more cephalic innervation, while a postfixed plexus has a larger contribution from lower roots such as the second thoracic. The variation in the position of the developing limb-buds thus determines the variation in the nerves which supply them, the prefixed plexus having a larger contribution from the fourth cervical segment. The lowest trunk of the brachial plexus is composed of the eighth cervical and first and second thoracic roots. With a postfixed plexus, these large contributions to the brachial plexus pass more obliquely upward to cross the first rib, or the cervical rib if such is present, before they turn downward to pass into the arm. It is much easier, because of their course, for them to be subjected to angulation, tension, and stretching. In the embryo, the elements of the nervous system are larger than the mesoblastic masses which later develop into ribs, and the neural elements affect the growth and form of these. The grooves which appear in bones and correspond with the course of nerves bear evidence of such a sequence of development. These are seen on the upper surface of the first rib and in the upper arm in the groove for the musculospiral nerve.

Anatomically, the lower roots of the brachial plexus and the subclavian artery arch upward and over the upper portion of the rib cage where they may be angulated abruptly. In addition to this angulation, these structures pass slightly forward, so that the scalenus anticus restrains them and holds them in a more dorsal position than they otherwise would assume. The anatomical relationships vary not only in different persons, but in the same person, depending upon posture and other factors, among which are the relation-

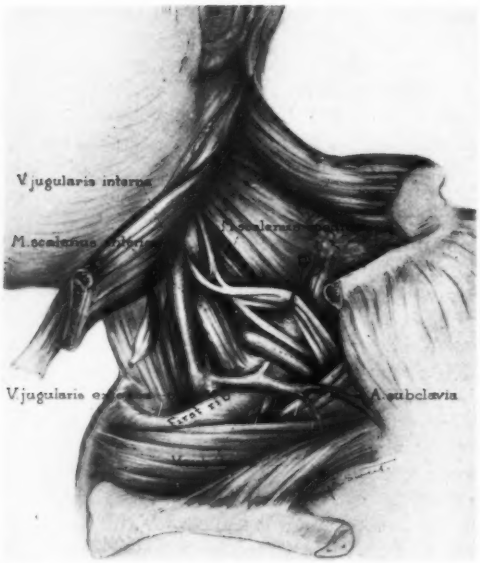

Fig. 1. Dissection of the left side of the neck to show the arrangement of the brachial plexus and subclavian artery as they curve over the first rib and behind the insertion of the anterior scalenus muscle.

ships of the position of the shoulder girdle to that of the thoracic cage.

Developmentally, in infants and children the relative position of the shoulder is high, but later, at puberty, a gradual descent occurs to the adult position. In the female the descent is greater, and the ultimate position of the shoulder is more sloping. This suggests a relationship between position and the greater incidence of the symptoms of cervical rib in women, and offers an explanation for the rarity of symptoms before adolescence.

The continued carrying of weights on the shoulder, as in hod carriers and soldiers, may be the immediate and exciting cause of symptoms. Loss of muscular tone and the drooping of the shoulders as seen in the aged, are other possibilities. The relative positions of the shoulder girdle and the rib cage are important, as indicated by the fact that deep inspiration and raising of the rib cage may cause an alteration in the pulse on the affected side, together with a change in blood pressure. Such an inequality between the two sides disappears when the arms are elevated. Many patients who have symptoms suggestive of tension on the brachial plexus have found that resting the elbow on the arm of a chair and leaning toward it so that the arm is supported, or resting the arm on a nearby table, or supporting it in a sling, or lifting the extremity by placing the other hand under the elbow, gives relief.

In this study, the records of 18 patients were reviewed. Twelve had no evidence of cervical rib; in 6 very small ribs were present, but were not seen at operation.

CASE REPORTS

CASE 1. Mrs. M. C., 40 years of age, entered the hospital on June 4, 1929, complaining of aching pain in the right shoulder and arm, of 5 years' duration. This pain spread over the outer surface of the upper part of the arm and the inner surface of the forearm to the right fourth and fifth fingers. One year before her admission to the hospital, the pain gave place to a feeling of numbness and occasionally of prickling, in the same area. The pain had always been worse when the patient lay on the right side, or on exposure to cold which caused the right hand to cramp in a claw position. For 2 years she had noticed a gradual wasting of the thenar eminence, more rapidly progressive during the year prior to admission. With this there had been great weakness of the thumb and first two fingers, without sensory disturbance. More recently, she had observed weakness and wasting of the right forearm.

Examination corroborated the patient's observations. In addition, there was a small area of diminished sensation to all forms of stimulation over the thenar eminence medially. The sensory loss was greatest in the area supplied by the right ulnar nerve. There was pronounced weakness of the muscles supplied by this nerve, less evident weakness of those supplied by the median nerve, and no apparent weakness in the muscles supplied by the radial nerve. The right arm was colder than the left. The blood pressure on the right was 105/80 and on the left, 120/80. The head was held deviated to the left. In the right supraclavicular fossa, firm pressure over the insertion of the scalenus anticus muscle caused considerable local pain and reproduced the tingling in the arm. Forcible turning of the head to the same side, hyperextension of the neck, or depression of the right shoulder caused an exacerbation of her symptoms. It did not, however, produce a fall in the right radial blood pressure.

On June 5, 1929, the right scalenus anticus muscle was exposed. It was under tension and exerted great pressure on the underlying subclavian artery which was forced back against the right brachial plexus. On dividing the muscle close to its insertion on the first rib, the subclavian artery bulged forward

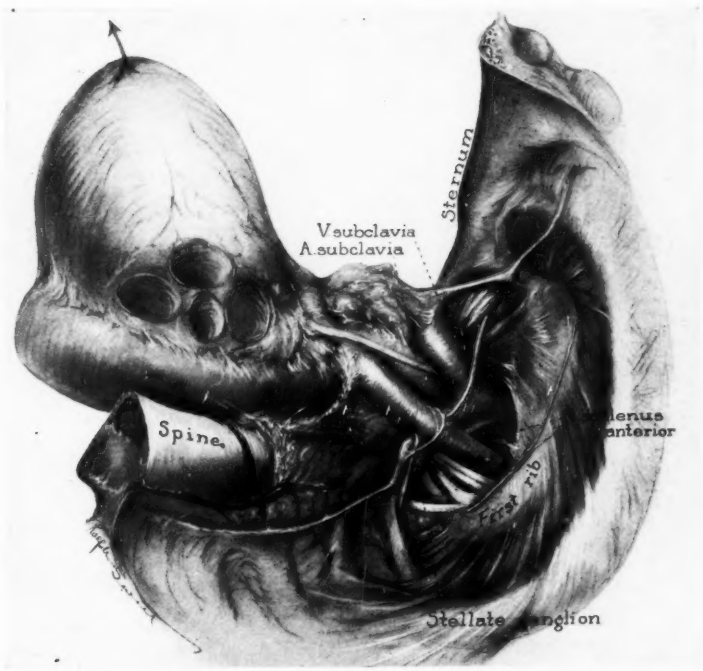

Fig. 2. Dissection of the structures at the apex of the thoracic cage, viewed from inside. The neurovascular structures may be seen in close relation to the first rib with the subclavian artery separating the brachial plexus from the anterior scalenus muscle.

and the brachial plexus behind it was no longer tense. Three days after operation the right arm was much stronger and, objectively, felt as warm as the other. The blood pressure was then 110/80 in the right arm and 112/80 in the left. The pain was entirely relieved and the patient was discharged from the hospital on the fifth day. Two months later, she had no complaints and both the right forearm and the right thenar eminence had begun to increase in size.

Many of the patients had similar histories, but a few presented other interesting symptoms and signs.

CASE 2. Mrs. L. P., 42 years of age, had suffered for a year and a half from a feeling of pressure on the outer side of the right shoulder, with numbness in the right fourth and fifth fingers. There was flushing of the skin of both arms as well as a peculiar tenseness of the skin on the right hand. X-ray examination of the cervical spine showed enlargement of the transverse processes of the seventh cervical vertebra, more evident on the right side. By measuring on the film, the transverse process of the seventh cervical vertebra was shown to be 1.1 centimeters longer than that of the first thoracic vertebra. At operation, the chief abnormality found was undue tension on the right subclavian artery. All complaints were relieved by myotomy of the right anterior scalenus muscle.

CASE 3. Miss I. B., 21 years of age, had noticed a severe dragging pain over the right scapula for 7 years which so interfered with movement of the right arm that she could not carry even a small bag without increasing the pain. Numbness and tingling were present over the ulnar side of the right hand and arm, with some weakness in the right hand. For relief, she held her head turned to the left and tilted to the right. With the patient at rest, the blood pressure in the two arms was equal, but with tension on the right scalenus anticus muscle, the right radial pulse disappeared and the blood pressure in the right arm fell to zero. In x-ray films of the cervical spine, the transverse process of the seventh cervical vertebra was only 1 millimeter shorter than that of the first thoracic vertebra, and the transverse process on the right was much larger than that on the left. At operation there was extreme pressure on both the right subclavian artery and the right brachial plexus. Eight days after myotomy of the

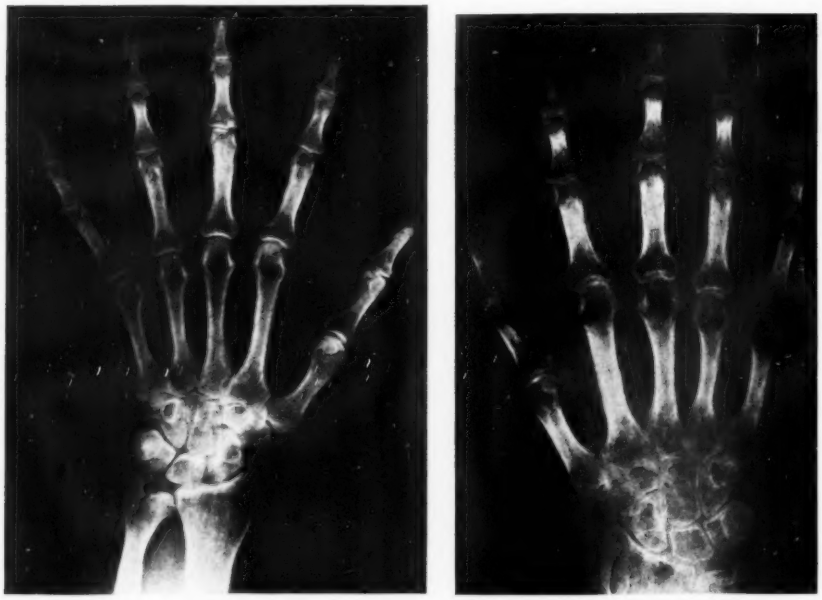

Fig. 3. Case 6. G. S. Roentgenograms of both hands of patient, demonstrating the advanced osteoporosis of the right phalanges, carpus, and even the bones of the forearm.

right anterior scalenus muscle the patient was free from symptoms.

CASE 4. Mrs. T. E., 31 years of age, had had sharp pain in the right hand for 6 years. The pain was worse at night. Three months after the onset pain was felt in the left hand as well and the patient soon noticed a constant tingling over the ulnar distribution on both sides. On 7 occasions she had experienced attacks of numbness over the entire right side of the face, arm, and hand, lasting for 1 hour each time and precipitated once by reaching down to pick up her baby. By auscultation above the clavicle on either side, a bruit could be heard when the anterior scalenus muscle was tensed. On exposure of the right scalenus anticus muscle it was found to have an attachment to the first rib over a distance of 5 centimeters. Myotomy was done. Within a few hours the patient was free from pain even when the right shoulder was strongly depressed.

CASE 5. R. F., a busy surgeon, 49 years of age, suspected that he had syringomyelia because he had suffered from aching over both trapezii for 12 years. This spread to the right side of the neck and the upper part of the right arm 8 months before admission. Numbness and tingling corresponding to the distribution of the median and ulnar nerves, had been present in the right forearm and hand for 6 months when he was first seen. Even the wearing of rubber gloves made the pain worse. He was also subject to hemicrania on the right, with visual phenomena pointing to the right hemisphere. After myotomy of the right scalenus anticus muscle, there was gradual but steady improvement, so that in 3 weeks he felt greatly improved. In 4 months he was almost back to normal and within a year, he was completely cured.

CASE 6. Mrs. G. S., 54 years of age, had felt a dull aching in both shoulders for 6 years, and a severe crushing pain in the right finger tips for 6 months. Finally she could move about only by carrying the right arm supported in a sling. The right pupil was larger than the left, but there was no other sign of Horner's syndrome. The blood pressure was the same in both arms. The tips of the right second, third, and fourth fingers were tender to firm pressure, as were the bases of all the metacarpals. The joints were swollen and tender; the bone showed marked osteoporosis and a diagnosis of atrophic arthritis had been made. On examination, the characteristic radiation of pain with some sensory change over the ulnar area and tenderness of the scalenus anticus muscle led to a myotomy of this muscle. Five days later the pain had entirely disappeared and one and one-half years following operation the only symptom that could be found in this patient was an occasional numbness of the tip of the right fifth finger.

CASE 7. Mrs. L. L., 52 years of age, had had severe, sharp pain over the precordium for a year and a half, and a diagnosis of angina pectoris had been made. Severe organic heart disease had followed a fever in early life. The pain was brought on by exercise only if the left arm participated, and it prevented her from raising the left hand to her head. There was also numbness in the left fifth finger. Although the pupils were equal, she had a narrower lid-slit on the left. The left radial pulse was weaker than the right; the blood pressure was 117/80 on the right and 110/70 on the left. She had been totally disabled by the severity of the pain for a year and a half, but 2 days after myotomy of the left scalenus anticus muscle, the pain was very much less. After 2 weeks it disappeared entirely and shortly thereafter she was able to resume her work as a physical therapist.

An analysis of the 18 cases studied disclosed the following findings: Among the 12 patients without cervical ribs the condition was twice as common in women as in men. The age of onset varied from 14 to 60 years, with an average age of 32 years, although the majority of patients were between the ages of 20 and 30. The duration of symptoms had been from 5 months to 15 years, with an average of 5 years. One patient was affected bilaterally. Of the others, 8 had symptoms on the right side and 3 on the left. A history of injury was obtained in 5 of the 12 cases.

Among the patients with rudimentary cervical ribs there were 5 females and 1 male. They were in a later age group, the average age of the onset of symptoms being 45 years. The duration of symptoms had been slightly longer than among those in the group mentioned above. The condition was bilateral in 1 patient, on the right side in 2, and on the left in 3. None gave a history of trauma. One cannot fail to be impressed by the wide variety of symptoms presented by these patients. One of the most common complaints is that of a heavy dragging sensation in one or both shoulders, or pain over the deltoid area, which at times extends down the arm often centering in and about the elbow. In more severe states, the pain extends down the forearm into the hand on the ulnar side; occasionally it may appear on the radial side. Certain forms of exercise of the extremity exaggerate the pain, and tenderness over the lower third of the scalenus anticus muscle immediately above the clavicle is unfailingly greater than normal. Other symptoms and signs are more variable. At times the pain is indicated as radiating up in the region of the trapezial fold or up into the cervical region or head. The patient may indicate discomfort over the region of the seventh cervical vertebra, which is sometimes relieved by extending the head and neck. In some, use of the extremity is prohibited by the production of pain, and the arm is carried in a sling. Others make the statement that certain acts, such as playing the piano or sweeping, are particularly likely to cause an increase in symptoms. A subjective feeling of numbness or sensory alteration over the ulnar area or even over the radial part of the hand is much more common than objective impairment of sensation. The latter, however, though mild, is not infrequent and is usually over the area of the ulnar nerve. Rarely has the condition gone on to more than a slight atrophy of the intrinsic muscles of the hand. In the scalenus syndrome, as in the majority of cases of cervical rib, marked circulatory alterations in the extremity are not frequent. In 1 patient without a cervical rib, however, the pressure on the subclavian artery was sufficient to occlude it. Gangrene of the terminal portion of the extremity resulted, and amputation was required. Milder evidences are not uncommon—for example, a blood pressure lower by 10 or 15 points on the affected side, an alteration in oscillometric reading, or perhaps some slight vasomotor change. In the English literature, Stopford called attention to the position of the sympathetic fibers which lie on the undersurface of the inner cord of the brachial plexus so that they are readily subjected to pressure. It is his belief that the circulatory changes in the extremity are brought about through the agency of mechanical pressure upon these sympathetic fibers. In our experience, however, it has been unusual to find marked circulatory alterations, though a larger series of these cases of scalenus syndrome might well reveal other striking instances of them.

Motor symptoms were usually late in appearing and, in many patients, an apparent loss of power was actually caused by the pain incident to strenuous effort. True weakness

occurred in the small muscles of the hand in 7 cases, with thenar wasting in 2. Weakness of the flexors of the wrist was found in 3 patients.

Without exception, the pain was brought on or increased by tensing the anterior scalenus muscle on the affected side. This was most commonly discovered on carrying objects with the arm extended, but could usually be elicited by passive depression of the shoulder, turning the head forcibly toward the affected side, or, in many cases, by any muscular effort of the arm. Conversely, in every instance, elevating the shoulder by supporting the elbow alleviated the pain immediately.

Examination of the neck consistently revealed tenderness over the insertion of the scalenus anticus muscle on the first rib. A drooping shoulder was seen in only 2 patients. In 4, the head was held tilted toward the affected side or slightly turned to the opposite side, in such a position as to relax the scalenus anticus. On auscultation above the clavicle, an arterial bruit was heard in 2 patients, while in 8, the radial pulse was diminished in volume by tensing the scalenus anticus muscle on the affected side. At rest, the blood pressure on the affected side was lower in 5 instances and higher in 3.

Evidence of sympathetic disturbance was present in 9 of the 18 patients. It consisted in flushing of the skin over the arm or hand, swelling of the hand, tenseness of the skin, cyanosis, brittle nails, rarefaction of bones, enophthalmos, migraine, and attacks of flushing over the blush area on the affected side. In 4 others the hand or arm was colder than its fellow, but this was assumed to be a direct effect of interference with the blood flow in the subclavian artery.

Among the patients seen have been many in whom the clinical picture seemed sufficiently typical to warrant a diagnosis of the scalenus syndrome, and yet the symptoms were comparatively mild, causing hesitation in advising operation. In a considerable number of these, improvement in the posture, exercises to strengthen the trapezius and the muscles elevating the shoulder girdle, have been followed by improvement and often by complete relief. It is our feeling that there must be a considerable number of persons in this less severe group, in whom properly directed exercises will be sufficient to effect a cure.

It is assumed that the scalenus syndrome occurs in persons who have an inherent variation in their development. Three of our patients had other abnormalities. One of them, with a bilateral scalenus syndrome, had more severe symptoms on the right side. She had, as well, a horseshoe kidney on that side, which required operation, and also a nodule in the right side of the thyroid. Another patient with the scalenus syndrome on the right, had right hemicrania with symptoms referable to the left side of the body. The third, had a flexed right fifth finger that was familial. Her scalenus syndrome was on the same side.

A history of trauma was obtained in 5 of the patients, none of whom had a cervical rib. It usually occurred shortly before the onset of symptoms and consisted in a blow from above on the affected shoulder so that it was forcibly depressed.

At operation there was, in every case, a definite tension on the subclavian artery and brachial plexus which were angulated against the scalenus anticus. This muscle was always firm, tense, and often appeared to be hypertrophied. On dividing it, the underlying structures were displaced forward and the brachial plexus was then seen to be lax. Sometimes the outer edge of the muscle sheath was thickened, its free outer edge constituting the point of greatest pressure on the subclavian artery. In none of the patients reviewed here was a cervical rib seen at operation, although, when present, it could usually be felt on deep palpation.

Relief from pain usually dated from the day of operation, and sometimes began immediately on recovery from the anesthetic. In some patients it was complete within a week after operation; in others it came about gradually over a period of from 1 month to a year. The hypesthesia cleared rapidly, often in a few hours. Among the motor signs, the generalized weakness of the extremity disappeared in a few days, indicating that it was secondary to the pain. Atrophied muscles began to increase in size in about 2 months. Recovery, though steady, was sometimes pro-

longed, necessitating a convalescence of as long as 8 months, but resulting in a return to work such as had been impossible before operation.

In half of the patients without cervical ribs, x-ray films of the cervical spine showed an enlargement of the transverse process of the seventh cervical vertebra so that it exceeded in length that of the first thoracic vertebra. This was possibly the result of overdevelopment of the costal element in the lateral mass of the seventh cervical vertebra. The transverse process of the seventh cervical vertebra was considered to be abnormally large if its tip extended beyond the limits of the first thoracic transverse process.

The present study of 18 cases emphasizes certain aspects of the scalenus syndrome. The bizarre symptoms and insidious onset render early diagnosis difficult, as does the fact that objective signs may appear relatively late. The early symptoms are usually vague pains about the shoulder. Their one common characteristic is that they bear a definite relation to exercise and to posture. Trauma to the shoulder may have preceded the onset of symptoms. The patient with precordial pain, first diagnosed as having angina pectoris, illustrates how one may be misled in the interpretation of a single symptom.

Realizing the congenital structural peculiarities and the other factors more immediately responsible for the onset of the syndrome, we believe that the production of symptoms depends upon an abnormal relationship of the shoulder girdle to the thoracic cage and its attached structures. This conception is the guide to treatment whether by exercises and correction of posture or by operation.

SUMMARY

The diagnosis of the scalenus syndrome is made in patients who have symptoms and signs suggestive of cervical rib, but in whom roentgenograms show either no cervical rib or at most a small outgrowth that could not itself be responsible for the disability.

The condition has been observed for some time and reported under various headings, most of which point to an abnormality of the first rib as the primary cause. In many respects the mechanism involved resembles that in patients with well developed cervical ribs.

The etiology consists largely in anatomical and developmental factors that result in an abnormal position of the shoulder girdle in relation to the thoracic cage. Embryologically, a postfixed brachial plexus is more readily subjected to tension and angulation in its course over the first rib and behind the anterior scalenus muscle. Injury, excessive occupational strain, or poor musculature may cause the shoulder to droop and precipitate the signs and symptoms.

The chief complaint of pain may be varied in character and distribution over the upper half of the body. The signs all point to a peripheral neuritis of the brachial plexus with striking relation to posture.

Myotomy of the scalenus muscle is required when postural exercises fail to relieve the symptoms. Operative results are excellent, though sometimes complete recovery takes several months.

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FURTHER STUDIES IN INFERTILITY AND STERILITY

An Analysis of 200 Couples

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SIX years ago we published the results of an analytic study of 300 couples (13) who sought advice because of their inability to conceive. Since that time, we have examined and treated an additional 200 couples for childlessness, the study and analysis of which is the basis of the present report.

The term, sterility, is used in this study to imply the *inability* to conceive, and by infertility, we mean any deviation from the normal level of fertilizability in the absence of a demonstrable cause for sterility. Infertility is a relative condition due to factors in one or both mates which, though often of a minor nature in themselves, in the aggregate constitute a definite barrier to conception. Thus, in dividing patients into the two groups, the matings wherein one or more accepted causes of sterility were demonstrated in either or both partners were classed as sterile. When none of the demonstrable causes for sterility was found, the mating was classed as infertile. In the latter group were included many apparently healthy childless couples in whom constitutional, endocrine, or other obscure factors played a part.

It is not within the scope of this paper to review all the literature on sterility or to name all those who made valuable contributions to the subject. One cannot, however, consider the subject of sterility without calling to mind such outstanding names as Huehner, for introducing the postcoital examination of the semen; Cary and Rubin, for devising a means of testing tubal patency, and the latter for his continued and intensive studies relative to the test; Dickinson, for his great interest in the manifold problems involved in the entire subject, and particularly for his contribution on cervical cauterization; Meaker, for clinic organization and the scheme for orderly and complete investigation and for stressing the importance of considering the *mating* rather than the male and female partners as individuals; and Ogino and Knaus, for their clinical and Hartman, for his biological studies of ovulation and the sterility-fertility relationship. In addition, Burr, Hill, and Allen, and Rubinstein have recently demonstrated methods of identifying ovulation time, and Davis and Koff were able by means of a hormone derived from pregnant mares' serum to stimulate artificially ovulation in the human. That many worthy contributions have been omitted from this brief introduction is obvious. I do not desire to repeat or even to summarize the mass of accumulated material in the literature on the subject of sterility, but shall attempt to emphasize certain points which I believe to be significant in considering the sterility problem from a practical standpoint.

The plan of investigation herein outlined (Chart 1) is generally followed by us. When interviewing the patients for factual data, in addition to the usual gynecological history, the physician should attempt to obtain a correct picture of the menstrual and sex life of the female partner and the sex habits of the couple. When the woman relates that menstruation is regular and normal, one should ask to see a record of her cycles. Very few women keep accurate records, and the physician will do a creditable service by educating his women patients in the advisability and value of collecting such data. It would be well if girls at puberty were instructed to begin records of their periods and keep them throughout their entire menstrual lives. I have been distributing calendar cards to my patients for the past few years and have urged their continuous use. By collecting the calendars each year, we are learning that the regu-

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Dr. Max Ballin Memorial Lecture, Detroit, Michigan, March 16, 1938.

Plan of Investigation

I. Male and female history
II. Physical examination
  Male
    A. General
    B. Urological
    C. Condom or ejaculate
  Female
    A. General
    B. Local gynecological
      1. Vagina and vulva
      2. Cervix
        a. Secretion
        b. Inflammation or polyp
      3. Uterus and adnexa
    C. Laboratory
      1. Complete blood; Wassermann and Kahn; urine; blood pressure
      2. Cervical smears
      3. Endometrial biopsy
III. Female
  Postcoital examination (Huehner test)
    A. Microscopic examination of vaginal pool (1 to 2½ hours after coitus)
    B. Microscopic examination aspirated cervical mucus
IV. Female
  Tubal patency (Rubin test)
    A. Carbon dioxide gas
    B. Pneumoperitoneum
    C. Uterotubography (separately or combined)
V. Male and female
  Endocrine

Chart 1.

lar menstrual cycle is a rarity and that irregularity is the rule. It is quite obvious that no intelligent consideration of the relatively sterile and fertile phases of the cycle is possible without accurate data and that the usual history taking technique is unreliable for this purpose.

A history of sex habits usually relates to the frequency of coitus and the occurrence of libido, orgasm, and variations of sex desire in the cycle, but it is important, from the standpoint of sterility, to inquire particularly whether coitus occurs in the estimated fertile phase of the cycle. I have observed instances in which failure to conceive apparently was due to coitus restricted to the pre- and postmenstrual phases of the cycle. A change in sex habit in this regard, and following the "rhythm" in reverse resulted in conception. Many patients still believe that fertility reaches its maximum around the menstrual period.

Inquiry into the previous use of contraceptives should be made, particularly as to whether a vaginal method or an intrauterine device was employed, and how long a period has elapsed since the patient ceased to use any contraceptive. Also, it is important to ascertain whether lubricants were being used to facilitate coitus inasmuch as most of the lubricants in general use possess contraceptive qualities. On the other hand, if contraception was apparently successfully employed with a method known to be of little merit. it would indicate the probability of sterility antedating its use.

Many patients will deny a history of venereal disease, and indeed they may be unaware that they ever had such infection, yet on inspection the astute observer discovers such stigmas as inflamed Bartholin's or Skene's ducts, or a mucopurulent cervical discharge; such findings definitely influence his opinion and put him on his guard concerning possible tubal damage or other sequelæ of infection, factors of importance in the sterility picture.

It is my conviction that many patients who present themselves for the diagnosis of sterility do not require a complete investigation, for at times obvious pelvic pathology is discovered upon the first examination. This may be of such a nature as to establish definitely a diagnosis of an absolute sterility as in certain extreme grades of underdevelopment (Fig. 1), or conditions requiring radical surgical treatment. Furthermore, the performance of the Huehner postcoital test may reveal an azospermia, which upon condom and urologic check up, indicates a male absolute sterility. In such instances, except as a matter of interest and study, further investigation of the female partner is unnecessary unless artificial insemination is contemplated.

The postcoital test in my opinion is one of the most important and sensible of our investigative procedures in sterility. By means of the test, we not only observe whether the male is fertile but at the same time learn to appreciate the obstacles which are naturally existent to the ascent of the spermatozoa.

First of all, the vaginal secretion, which is normally acid, is inimical to long survival of the spermatozoids; perhaps that accounts for the great excess of male gametes (100,000,000 in an average ejaculate). However, it is not uncommon to find, in addition to dead sperms, innumerable actively motile forms in the vaginal pool from 1 to 2 hours after coitus. The next barrier to be met with is the cervical secretion. While normally this is clear, thin mucus with an alkaline reaction, one often finds it pathologically altered. A thick, tenacious mucous secretion is considered an even more effective barrier to sperm migration than a frankly purulent one. Under the microscope, it is common to observe the difficulties that spermatozoa have in migrating through tenacious mucus and somewhat surprising to observe their rapidity of motion in a mucopurulent sample. Both conditions are pathologic, however, and call for suitable management, whether or not they are associated with cervical erosions, polyps, strictures, or other endocervical disease.

I usually arrange to carry out the Huehner test at my office and have encountered no difficulty, the patient having been properly instructed to have coitus at home an hour previous to the appointment and to avoid unnecessary loss of semen before arrival. An ample pool of liquid secretion is generally found in the receptaculum (without the additional aid of intravaginal containers), which I find fully adequate for microscopic examination. A wire loop or pipette is used for transferring the vaginal specimen to a slide. The cervical samples are obtained by means of a glass aspirating pipette and bulb, and these samples are considered by us to be of utmost importance in judging the quality of the male contribution. Whenever a large number of actively motile, normal-appearing spermatozoids are observed in the cervical mucus sample, I regard the test as a satisfactory one. When, however, a scant pool, few or no sperms in the vagina, and feeble or immotile sperms only are found in the aspirated cervical mucus, a condom specimen is requested and a urologic examination is advised. It often happens that the husband is unwilling to co-operate beyond sending a condom specimen and even in cases in which the semen is found to be substandard or completely deficient, the husband often refuses examination, thus leaving the investigation incomplete.

A general physical examination should be made of both partners. The genital status should be noted and evidence of developmental anomalies and of inflammatory disease particularly sought. On gynecological examination, the real infantile uterus is truly a rarity, but various grades of hypoplasia are commonly encountered. Whether called juvenile or prepubertal, the hypoplastic uterus is usually an indicator of endocrine deficiency resulting in genital underdevelopment. The ovarian deficiency or immaturity which accompanies hypoplasia is indeed significant and may be directly responsible for the uterine condition. Measurement of the uterine index (Meaker) may serve as a gauge of the functional capacity of the uterus. Other genital tract anomalies, such as those resulting from errors of fusion, may escape detection upon pelvic examination, to be discovered later in the investigation by means of x-ray examination. Various forms of septate, arcuate, bicornuate (Fig. 2) and the so called double uterus may be found, associated with or without a septate or double vagina. In the latter instance, a thick septum may require division in order that coitus be made possible. I have encountered 2 instances of failure of intromission for 1 and 5 years, respectively, because of septate or double vagina. It is worthy of note, however, that the ovarian development is usually not impaired in these various types of fusion defects and consequently conception occurs more readily than in hypoplasia.

Uterine displacements, flexions, and versions do not play so important a rôle in the etiology of sterility as was formerly believed. Acute anteflexion is usually associated with hypoplasia and indicates that ovarian rather than uterine function is primarily at fault. Retroversion in itself is not, as a rule, a serious barrier to conception since many patients are observed to have uterine retroversion but experience little difficulty in becoming pregnant.

Gross pathological lesions of the intrapelvic viscera may be discovered upon examination, such as multiple fibroids, tumors, and cysts of the ovaries, and inflammatory lesions of the adnexa. The tumors may require removal before proceeding with the sterility tests. Chronic inflammatory conditions are of particular interest in that they signify demonstrable damage to the fallopian tubes. Tubal obstruction as a result of the inflammatory disease, in which gonorrhea plays so significant a rôle, is one of the most tangible causes of female sterility. In the study of tubal obstruction, great strides have been made through the employment of the Rubin test and hysterosalpingography. The additional aid of pelvic pneumoperitoneum has proved in my hands (8) to be of material assistance in visualizing the extent of the damage and in recording the pelvic status (Fig. 3).

In cases in which the Huehner test has proved satisfactory and when no contra-indication exists, tubal patency tests are routinely made in the office. Frequently, both tests are performed at the same visit, while motile spermatozoids are in the cervix and corpus uteri, in the belief that by this means the sperm migration through the oviducts may be facilitated. I have never observed any harm resulting from thus combining the Huehner and patency tests. For testing tubal permeability, the Rubin kymographic apparatus (5) is satisfactorily utilized in conjunction with the author's self-retaining cannula set (10), obviating the necessity of holding or manipulating the instruments during the test. In this way, the examiner is free for simultaneous auscultation over the tubal areas and observance of the tracing on the kymographic drum. The procedure is familiar to all gynecologists and there is no need to enter into details at this time. When obstruction is apparent, by recorded pressures up to 200 millimeters of mercury, repeated tests are indicated. Our second test is usually performed in a special room in the x-ray department at Michael Reese Hospital where appropriate apparatus is available for testing with carbon dioxide, instillation of iodized oil for roentgenographic purposes, as well as a suitable table (11) for taking pneumograms with the patient in the modified knee-chest position. This is the desired posture for obtaining satisfactory roentgenograms after the production of pneumoperitoneum. A repeat Rubin test with carbon dioxide is made, this time the patient having been prepared with a cleansing enema 2 hours previously, followed by a dose of morphine and scopolamine, to act as an antispasmodic analgesic. If no obstruction is met, 1 liter of gas is allowed to pass into the peritoneal cavity and x-ray films are taken. If, however, obstruction is again encountered, the gas is introduced by the transabdominal route, and lipiodol is instilled after the patient is in the knee-chest posture. One film is usually made of the pneumoperitoneum alone and subsequent films with the combined pneumoperitoneum and uterosalpingography. Additional films are taken at intervals of a few minutes to many hours to determine whether the obstruction is due to mechanical closure or merely to spasm. Frequently, 18 or 24 hour films are required to demonstrate the presence or absence of intraperitoneal spill. Thus, hysterosalpingography and pneumoperitoneum are used to complement or supplement the information obtained by means of the Rubin test, all of which is of extreme value in arriving at a correct diagnosis.

By means of the combined uterosalpingography and pelvic pneumoperitoneum, the pelvic status may be clearly visualized on the roentgen film. The iodized oil indicates the character of the uterine cavity and tubal lumens, site of tubal obstruction, or permeability, and the gas permits organ outlines and relationships to be clearly registered by means of the contrasting gaseous medium.

The development of these methods of roentgen visualization of the pelvic organs has indeed been a most useful diagnostic aid, particularly in the study of sterility, but also in the diagnosis of obscure and disputed gynecological conditions in general. From an experience of many years, I can heartily recommend their employment as a part of the sterility study. It has been repeatedly shown that pneumoperitoneum by the transuterine or transabdominal route is free from danger, and that the x-ray films of the pelvic organs

TABLE I.—INVESTIGATION OF 200 COUPLES

			Cases
Primary			146
Secondary			54
Infertility (relative)			103
Sterility			97
Relative—Male	25	Female	69
Absolute—Male	11	Female	8
Total	36		77
Both	16		

Duration of involuntary barrenness:
—1 to 20 years; average, 3.3 years.

TABLE II.—ETIOLOGY OF FEMALE STERILITY

Etiological factor	No. of cases	Etiological factor	No. of cases
No apparent	73	Previous abortion	9
Cervicitis; erosion	35	Bicornuate uterus	3
Hypoplasia	23	Hypomenorrhea	2
Tubal obstruction, complete	15	Polymenorrhea	1
Tubal obstruction, partial	5	Pelvic mass	2
Ovarian cyst	13	Cervical stenosis	2
Bilateral polycystic Ovary	12	Anemia	2
Obesity	12	Hypothyroidism	2
Retroversion	10	Hyperthyroidism	1
Adhesions	9	Prolapse	1
Fibroids	7	Intact hymen	2
		Vaginismus	1
		Previous laparotomy	47

obtained in this manner possess a greater diagnostic value than those taken with transuterine contrast media alone. When both methods are used together, one is able to ascertain the maximum information concerning the structure, development, alteration, and relationship of the pelvic organs short of actual laparotomy.

The relation of endocrines to sterility is a chapter by itself. I feel that much has been accomplished in the past few years in the study of the hormones but likewise believe that many of our present views concerning their actions will be altered in the future. The most promising developments in relation to the sterility problem seem to me to be the identification of ovulation time, the establishment of facts regarding single or multiple ovulation in the cycle, further evidence of viability or fertilizability of ova, and accumulation of more clinical data upon the fertility-sterility relationships in the sex cycle.

Endometrial biopsy obtained by suction curette (4) or other suitable instruments may prove of value in determining whether or not ovulation occurs; when performed in the premenstrual phase of the cycle, it is presumed that no ovulation has occurred if the sections reveal only the proliferative non-secretory stage. The bleeding in such a case is anovulatory in type. Unless ovulation occurs, followed by corpus luteum formation, the secretory phase of the endometrial cycle is absent. Davis and Koff showed that follicle ripening can be stimulated artificially in the human by the injection of gonadogen (hormone from pregnant mares' serum) at any phase of the cycle and that frequently more than 1 ovum is thus produced. In half of their cases, ovulation occurred in 18 to 36 hours after injection. Other studies (7) indicate that 2 ovulations occur regularly in the cycle. This, however, is not borne out by the work of Rubinstein, Burr, and others. The Ogino-Knaus theory limits fertility to about 5 days in the mid-interval, with the fifteenth day before menstruation as the definite ovulation date. On the other hand, the recognized infrequency of regular menstrual cycles and the undoubted occurrence of conceptions in the so called "safe period" are evidences that ovulation may not bear the accepted constant time relationship to menstruation in many women (12).

The present study is based upon the analysis of 200 couples examined in private practice since our previous report. Infertility plays a greater rôle in the present incidence, as 103 matings are so classified as against 97 in the sterility grouping. In our former series, there were 57 infertile and 243 sterile couples. In both groups, primary infertility or sterility occurred about 3 times as frequently as did secondary. The incidence of male and female factors and proportion of absolute and relative sterility are shown in Table I.

In the list of etiological factors, uterine hypoplasia, tubal obstruction, previous abortion, and chronic endocervicitis continue to play a significant part (Table II). The male partner is shown to be directly responsible in slightly over one-third of the cases of sterility, and among the infertilities, substandard sperm specimens were not infrequently revealed. Huehner tests were carried out in 125 couples, and in cases of unsatisfactory results, condom and urological tests were routinely requested.

TABLE III.—STERILITY TESTS

Test	No.
Huehner's postcoital	125
Rubin patency	111
Lipiodol	42
Pneumoperitoneum, alone or combined with lipiodol	41

TABLE IV.—SURGICAL TREATMENT OF STERILITY GROUP (FEMALE)

	No. of cases		No. of cases
Cautery	26	Hysterectomy	2
Ovarian resection	14	Manchester plastic	1
Bilateral	9	Suspension	1
Dilatation and curettage	8	Bladder advancement	1
Myomectomy	4	Trachelorrhaphy	1
Salpingostomy	1	Perineorrhaphy	1
Perineotomy	1	Salpingo-oophorectomy	4
Hymenal incision	2	Lysis of adhesions	4
Oophorectomy	2		

Tubal patency tests were done in 111 cases, hysterosalpingography in 42, and pelvic pneumoperitoneum by the transuterine or transabdominal route in 41 cases. Tubal obstruction was encountered in 20, of which 15 were complete and 5 partial. The incidence of this cause in the sterility group is approximately the same as in our first series (20 per cent). We have continued the practice of performing the Rubin test immediately following Huehner's test in suitable subjects as both expedient and practical, and have had no occasion to regret this practice. In fact, we feel that conditions for fertilization are favored by this sequence of procedures, carried out within a few days of the estimated time of ovulation.

Surgical measures were carried out in 73 patients (Table IV). Linear cervical cauterization was the most frequently employed measure and has continuously proved to be satisfactory. Occasionally, a second treatment, using the Kimble or Hyam method, was required. Salpingostomy was performed in only 1 case in this series (without benefit) and no tubal implantations were done. The most interesting and most hopeful group from a surgical standpoint is that of 9 cases of sterility due to bilateral polycystic ovaries. In 5 of these, *amenorrhea* was a feature of the clinical picture. The diagnosis of significant ovarian swellings (Fig. 4) in each case was established by x-ray after pneumoperitoneum, and bilateral cortical wedge resection resulted in the prompt return of the menses, general systemic improvement, and restored fertility. We have previously described this condition and its treatment (9), and have operated upon 32 patients to date with gratifying results. Many of these operations were upon single girls, obviously not included in this series, whom we have had occasion to observe for several years. After marriage, they continued to have normal menstrual periods, and some of them have borne children. In none of the cases of wedge resection have we discovered recurrence of cystic ovaries.

TABLE V.—PREGNANCY FOLLOWING INVESTIGATION AND TREATMENT

	No.	Per cent
Infertile matings	103	
Pregnancies (1 tubal)	51	49
Sterile matings	97	
Pregnancies (1 tubal)	15	15.4
Matings	200	
Total pregnancies	66	33

From the large percentage of pregnancies (Table V) which occurred in the group here reported, it is apparent that a considerable proportion of the matings were only relatively infertile and the minority were really sterile. There can be but little doubt that if given time, a certain proportion of apparently infertile women eventually succeed in becoming pregnant without investigation or treatment, as occurred in 9 of the patients in this series. On the other hand, among couples apparently healthy, pregnancy is often delayed for an indefinite time even though no contraceptive is used, and an investigation is urgently requested by them. In others, pregnancy follows immediately after the Huehner and patency tests are performed and before any other treatment becomes indicated. This fact strengthens our belief that the patency test with gas or with opaque media has therapeutic as well as diagnostic value. Pregnancy occurred in 15.4 per cent of the sterile matings after treatment of one or both mates, and in 49 per cent of the infertile matings. In 5 of the latter, repeated pregnancies occurred. This incidence of 33 per cent for the 200 couples is decidedly higher than in our previous series (19.3 per cent). It is our feeling that instruction in sex habits, timing

Fig. 1. Transabdominal pneumoperitoneum. Patient aged 21, primary amenorrhea. Extreme genital hypoplasia (fetal type). A diagnosis of absolute sterility was made.

Fig. 2. Transuterine pneumoperitoneum and hysterosalpingography. Bicornuate uterus, patent tubes, right cystic ovary. A diagnosis of relative infertility was made.

of coitus in relation to the estimated fertile phase of the cycle, and general measures have been helpful (Table V). Glandular therapy played but a small part, its chief virtue resting in thyroid extract. Estrogenic preparations were used in the treatment of hypoplasia and despite little change in the uterine size, pregnancy sometimes occurred. One hesitates, however, to credit the results to the therapy employed in a small series. Of many hormonal preparations tried from time to time, no striking results have been observed with any particular preparation. The hormone now available from the serum of pregnant mares has been shown to stimulate ovulation in the human, and it is highly probable that this agent will prove of practical value in certain types of sterility. Favorable results should be expected from such therapy in minor grades of hypoplasia associated with immature or inactive ovaries, and in cases of anovulatory bleeding. When the ovaries have become polycystic, however, no result can be expected from hormone therapy. Surgery is then indicated.

CASE REPORTS

Case 1. M. W., aged 28 years, married 6 years, nulligravida. Patient's menses were always irregular, occurring every 5 to 6 weeks. The Huehner and patency tests proved satisfactory. X-ray films taken after transuterine pneumoperitoneum revealed bilateral polycystic ovaries. A wedge cortical resection was performed on January 7, 1936. Menses immediately after became regular until May 25, 1936, when the patient became pregnant and delivered at term.

Diagnosis: Female sterility. Operative treatment restored fertility.

Case 2. S. S., aged 32 years. Secondary sterility, 4 years. Patient had had previous abortions. The Huehner and patency tests proved satisfactory; amenorrhea followed tests. A laparotomy was carried out 2 months later for a ruptured ectopic pregnancy.

Diagnosis: Infertility. Tubal pregnancy followed patency test.

Case 3. H. S., aged 29 years, married 8 years. Patient's menses were irregular and profuse occurring every 28 to 32 days. Curettage revealed a polypoid endometrium. The Huehner and patency tests proved satisfactory. X-ray films taken after pneumoperitoneum revealed a few small fibroids and a cystic left ovary. At laparotomy, myomectomy, ovarian resection, and appendectomy were performed. Patient became pregnant 8 months later.

Diagnosis: Female sterility. Operative treatment restored fertility.

Case 4. M. S., aged 30 years, married 5½ years, nulligravida. Patient's menses were regular. Her uterus was hypoplastic. Patient was given sistomensin for dysmenorrhea. The Huehner and patency tests proved satisfactory. Rhythm for fertility was advocated. Second Huehner and patency tests were

Fig. 3. Transuterine pneumoperitoneum and hysterosalpingography. Left adnexa previously removed surgically. Right tube patent to gas and fills with opaque media; right ovarian cyst. A diagnosis of secondary sterility was made.

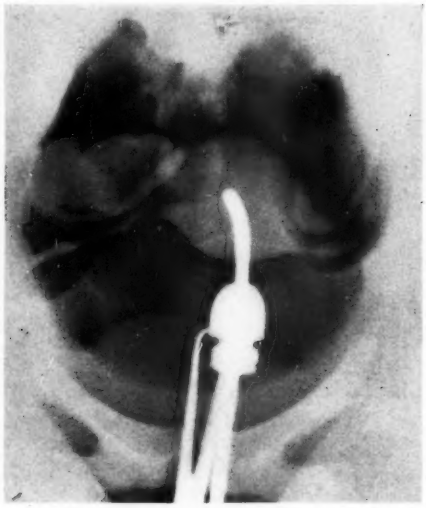

Fig. 4. Transuterine pneumoperitoneum. Patent tubes. Bilateral polycystic ovaries. A diagnosis of primary sterility was made.

followed immediately by pregnancy and patient delivered at term.

Diagnosis: Infertility. Fecundity restored after repeated patency tests.

CASE 5. S. W., aged 23 years, married 2½ years, nulligravida. This patient complained of sterility and failure of intromission. Her husband was operated upon twice for hypospadias. However, the operations were unsuccessful and resulted in a sharp ventral curve of the phallus on erection. The ejaculate specimen on examination proved satisfactory. Artificial insemination was carried out on five occasions at the time of estimated ovulation. A patency test was followed by pneumoperitoneum. The films revealed bilateral polycystic ovaries. A wedge cortical resection was done. Artificial inseminations were repeated after 6 regular menstrual periods without result. Intravaginal injection of sperm following attempted coitus was advised. The husband was referred to a urologist but refused further surgery.

Diagnosis: Male and female sterility. Surgical treatment of both partners. Failure.

CASE 6. C. L., obese, orthodox Jewess, aged 31 years, married 2 years. Patient's menses were irregular occurring every 21 to 26 days. Coitus was omitted during the first 2 weeks of the cycle. The Huehner and patency tests proved satisfactory. Thyroid medication and diet and change of sex habits were advocated. Patient lost 15 pounds in weight. The second Huehner and patency tests proved satisfactory, for they were followed immediately by pregnancy and the patient delivered at term.

Diagnosis: Infertility. Fecundity restored by thyroid medication, diet, sex adjustment, and repeated patency tests.

CASE 7. M. L., aged 27 years, married 7 years. Patient's menses were irregular. The Huehner test revealed necrospermia. The patency test proved satisfactory. The Huehner test was repeated after urological treatment and showed a few active spermatozoa. The patency test again proved satisfactory. Pregnancy immediately followed and the patient delivered at term.

Diagnosis: Male sterility. Fecundity restored after treatment of male.

CASE 8. A. L., aged 20 years, married 16 months, nulligravida. Male aspermia. X-ray films taken after pneumoperitoneum revealed a right dermoid cyst. At laparotomy a right oophorectomy, left ovarian resection, and appendectomy were performed. At a second laparotomy 5 years later myomectomy was performed. Five years later at a third laparotomy hysterectomy for multiple fibroids was carried out.

Diagnosis: Male and female absolute sterility.

CASE 9. A. C., aged 32 years, married 8 years. The Huehner test revealed necrospermia. Urological therapy was carried out but no improvement occurred.

Diagnosis: Male sterility.

CASE 10. E. H., aged 30 years, married 5½ years. The Huehner test revealed necrospermia. Urological examination revealed unsatisfactory sperm. The Rubin test proved non-patency. A tubal obstruction was present.

Diagnosis: Male and female absolute sterility.

CASE 11. L. F., aged 31 years, married 2 years. Menses were irregular occurring every 1 to 5 months. X-ray films taken following pneumoperitoneum revealed bilateral polycystic ovaries. A wedge cortical resection was done. The menses became regular and pregnancy occurred 1 year later. A spontaneous 5 month miscarriage resulted.

Diagnosis: Female sterility. Fertility restored following ovarian resection.

SUMMARY AND CONCLUSIONS

1. In this analysis of 200 childless couples, infertility was more frequently encountered than sterility.

2. The male partner was responsible for about one-third of reproductive failures.

3. Roentgenographic methods (pneumoperitoneum and hysterosalpingography) were of material value in the investigation of the female partner.

4. Pregnancy occurred in almost half of the matings in the infertility group and in only 15.4 per cent in the sterility group after investigation and treatment.

5. Successful treatment in the infertility group was chiefly attributable to cervical cauterization, patency tests, and sex adjustments. In the sterility group, hormone therapy in the male and surgical treatment in the female were at times successful.

Note.—I gratefully acknowledge the valuable assistance of my colleague, Dr. M. L. Leventhal, and my associates, Dr. M. R. Cohen and Paula Bennett, in preparing the material for this paper.

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SURGICAL ANATOMY OF CAROTID SINUS NERVE AND INTERCAROTID GANGLION

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THE term carotid sinus (bulbus or sinus caroticus) is applied to a dilated portion of the internal carotid artery, which lies just above the division of the common carotid artery into its two main branches. This particular segment of the internal carotid artery which has been known for a long time is also present—though is less developed—in children, and may also be demonstrated in embryos and in animals of every species. In those animals in which the rôle in the cerebral circulation is dominated by the occipital artery, the dilated zone is located at the mouth of the latter and not on the internal carotid artery.

The walls of the carotid sinus possess characteristic histologic features—an onion-like structure (15) and thinness which is due mainly to the reduced size of the media. The external tunic consists of a wide network of elastic fibers while the intima is hyperplastic. Ask-Upmark (1935) emphasized the thickening of the adventitial tunic which is provided with a special system of receptors between the collagenous layers (especially well developed in the widest portion of the sinus). On the other hand, Druener found no difference between the histologic features of the carotid sinus and those of the carotid artery as a whole.

The nerve supply of the carotid sinus is known under different names: ramus caroticus n. glossopharyngei (Brauecker), ramus descendens n. glossopharyngei (Druener), and sinus nerve (Knoll, Hering). The sinus nerve and its anastomoses with the vagus nerve are pictured in the atlas of Spalteholz (Fig. 776), but is nowhere mentioned in the text.

Sinus nerve. While accepting Hering's term "Sinusnerv," one should bear in mind the complex relations between this nerve and the intercarotid ganglion and that the nerves emanating from the carotid sinus do not terminate in its walls but continue their courses over the common carotid artery giving up terminal twigs to the thyroid, thymus, and pericardium. For this reason Druener rejected Brauecker's designation "ramus caroticus n. glossopharyngei" and suggested the name "ramus descendens n. glossopharyngei." F. de Castro enumerated a number of nerves that form the plexus surrounding the carotid ganglion and particularly emphazised a nerve called by him "nervus intercaroticus." According to Sunder-Plassmann and others, this nerve does not remain isolated in its course but forms anastomoses with other nerves. Ask-Upmark, Cordier and Coulouma stated that the different nerves connected with the carotid sinus form loops and thus give rise to complicated structures of which at least five can be differentiated. Hovelacque, Maes, Binet, and Gayet maintain that the carotid sinus branches usually arise (with two branches) from the main trunk of the glossopharyngeal nerve 1 centimeter below its emergence from the cranial cavity and that only rarely do they originate from the pharyngeal branches of the glossopharyngeal nerve. In their further course down the internal carotid artery the foregoing nerves form anastomoses with the branches from the vagus and sympathetic nerves, thus participating in the formation of the carotid plexus.

Observations of Binet and Gayet, Brauecker, Danielopolu and others justify the conclusion that the innervation of the carotid sinus is usually supplied by the glossopharyngeal nerve itself and less frequently by its pharyngeal branches. In its course, the glossopharyngeal nerve forms anastomoses with the pharyngeal branches of the vagus, superior cervical sympathetic ganglion, and, only occasionally, with the superior laryngeal nerve.

From the laboratory of Experimental Neurosurgery of the Central Psychoneurological Institute (Prof. Z. J. Heymanovitch, Head of Laboratory); translated by Prof. L. J. Nemlicher (Kharkov, U.S.S.R.) and edited by Dr. George B. Hassin (Chicago).

Carotid body. The carotid body, also known as ganglion or paraganglion intercaroticum, glandula carotica, glomus caroticus, has been described in mammals, birds, and reptiles and was presumably identified in amphibia and fishes (Ask-Upmark). There are a number of hypotheses as to its origin. It was, for instance, assumed to be in the pharyngeal wall, sympathetic plexus, or in the adventitial tunics of the carotid vessels (Hammar). Hering thought with some reason that the carotid body belongs with the glands secreting a specific substance in the nature of adrenalin, the presence of which, however, could not be demonstrated by Aszodi and Paunz in the carotid body of rabbits.

Whatever the nature of the carotid body, it is definitely established that it is connected with the carotid sinus and receives branches from numerous nerves (glossopharyngeal, sympathetic, upper laryngeal, vagus, and hypoglossal). Some investigators (Ask-Upmark, Princeteau, Gerard and Billingsley, and others) speak of branches derived also from the intercarotid plexus which, as has been emphasized, is formed by the sympathetic, vagus, glossopharyngeal, and, partly, by the hypoglossal nerves.

F. de Castro described a periglandular nervous plexus of the carotid body. Such a plexus is formed by single branches of the upper cervical sympathetic ganglion, intercarotid nerve *in toto*, a branch of the glossopharyngeal nerve, and the pharyngeal branches of the vagus nerve.

PERSONAL OBSERVATIONS

On the whole, the problem of the carotid body and its nerve supply has been studied mainly in its relationship to the heart and aorta and in a rather small number of specimens. The reason is that the ordinary methods of dissection of the delicate nerve twigs are time consuming and the nerve twigs are easily damaged, thus necessitating repeated dissection of certain parts of cadavers which must be fresh always. The largest number used for such studies was by Cordier and Coulouma (15 cadavers) while in my work I used 35. The dissection was done by the method of Worobiew and was not confined to the neck but extended to the regions of the head innervated by the second and third branches of the trigeminal nerve. These additional dissections enabled me to investigate the connections of the trigeminal areas with the carotid sinus and to give a morphologic explanation for the painful syndromes of the temporal and parietal regions as described by Heymanovitch.

PERSONAL INVESTIGATIONS

I used only fresh cadavers which had not been preserved in special fluids, such as a solution of formaldehyde. The head was sawed sagittally into two equal parts in which two topographic regions (regio colli and regio capitis) were carefully mapped out. An incision of the skin was made along the lower border of the mandible and extended underneath the ear, through the mastoid, and down the lateral border of the trapezius muscle; a thread was passed through the incised border and by pulling it up it was possible to demonstrate the superficial muscles of the neck. By turning upward and downward the cut segments of the platysma and sternocleidomastoid muscles one could see the region of the carotid arteries. The specimen then was kept for 1 or 2 hours under a continuously flowing stream of water which made the cellular tissues friable and easy to dissect by Worobiew's method (under constantly falling drops of water). The falling of the drops caused further swelling of the tissues and made it possible to demonstrate macroscopically the minutest ramifications of nerves scarcely visible even when dissected with the finest anatomic pincers and special needles. It was thus possible to visualize (from the side of the skin) the topography of the carotid sinus nerve, its relation to the carotid artery, and some of its connections with nerves which could be studied at a given level. In order to make visible the origin of the carotid sinus nerve, we had to cut through the dorsal half of the digastric muscle; to shift laterally; to remove completely in some cases even the internal jugular vein; and to raise the border of the parotid gland. This also enabled me to study the cranial nerves at the place of their emergence from the jugular foramen. Removal

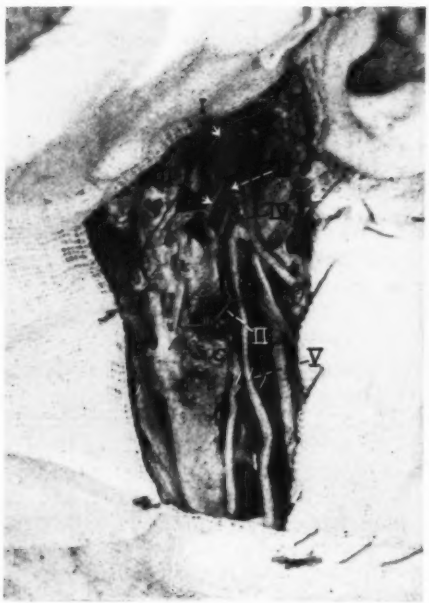

Fig. 1. Illustration of the course of the carotid sinus nerve from its origin (the glossopharyngeal nerve). *I*, Glossopharyngeal nerve; *II*, carotid sinus nerve; *III*, pharyngeal branch of the vagus nerve; *IV*, superior laryngeal nerve; *V*, superior cervical sympathetic ganglion; *s.c.*, carotid sinus.

Fig. 2. Connections between the carotid sinus nerve and the vagus nerve. *I*, Glossopharyngeal nerve; *II*, the pharyngeal branch of the vagus nerve; *III*, carotid sinus nerve; *IV*, accessory nerve; *V*, anastomosis between the carotid sinus nerve, *III*, and vagus nerve, *VI; VI*, vagus nerve; *s.c.*, carotid sinus.

of the anterior wall of the latter (with Luer's small tongs) served the same purpose very well. In cases in which we intended to determine more accurately the connections between the sympathetic, vagus, and superior laryngeal nerves, the dissection was begun from the median plane of the head. This made it possible to follow up the origin of the anastomoses between the carotid sinus nerve and the carotid body, and in addition to demonstrate the terminal branches of the nerves which descend along the posterior wall of the common carotid artery.

To fulfill my second task—the demonstration of the anastomoses with the ganglia of the second and third branches of the trigeminal nerve—it was necessary to lay open the mastoid region, open up the tympanic antrum (as it is done in the radical operation of Stacke), facial canal, and tympanic canal. This enabled me to trace the tympanic nerve from its place of origin in the glossopharyngeal nerve and follow up its further course as superficial petrosal nerve to the otic ganglion. This is well illustrated in specimens in which the mandibular nerve has been dissected from the inner side and the internal pterygoid muscle has been turned down in the middle part of its upper border. In the same specimen one could study the superficial petrosal major nerve and its anastomosis with the tympanic nerve. In order to demonstrate its further course—under the name of vidian nerve—to the sphenopalatine ganglion as well as the ganglion itself, I prepared a series of specimens in which the foregoing structures may be seen both from the side of the skin of the face and the median (the sawed) plane of the head. For the latter purpose, I removed a part of the body of the basal bone and opened the pterygopalatal fossa and the palatal canaliculi, while in order to get easier access

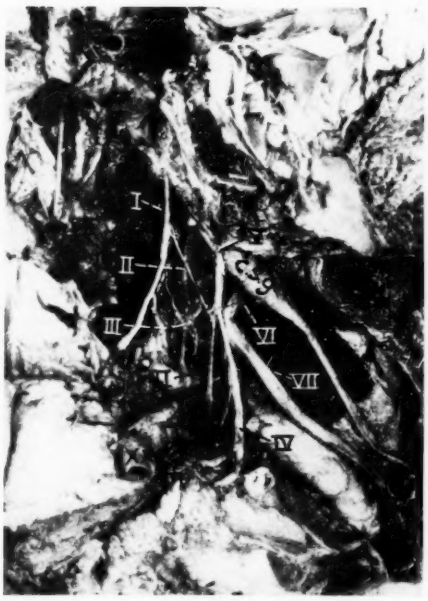

Fig. 3. Illustration of the relationship between the superior cervical sympathetic ganglion, *c.s.g.*, carotid body, *III*, and the carotid sinus nerve, *II*. *I*, Glossopharyngeal nerve; *II*, carotid sinus nerve; *III*, carotid body; *IV*, superior laryngeal nerve; *V*, a branch from the carotid body, *III*, to the superior cervical sympathetic ganglion, *c.s.g.*; *VI*, anastomosis between the carotid sinus nerve and the superior cervical sympathetic ganglion; *VII*, vagus nerve; *XX*., internal carotid artery.

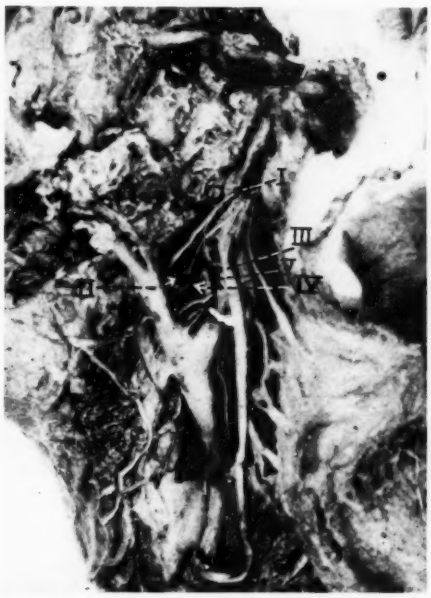

Fig. 4. This figure illustrates the anastomosis, *IV*, between the carotid body, *II*, and the superior cervical sympathetic ganglion, *V*. *I*, Glossopharyngeal nerve; *III*, vagus nerve.

to the pterygopalatal fossa from the side of the skin of the face, it was necessary to open the pterygoid canal, after the outer wall of the orbit had been previously removed.

As dissected specimens usually give poor photographs, hand drawings are sometimes preferable and one is supplemented in this paper for a photograph.

ANATOMIC CONSIDERATIONS

Figure 1 shows the carotid sinus nerve, *II*. The nerve originates by two twigs from the stem of the glossopharyngeal nerve *I*, 1.5 centimeters below the point of its emergence from the cranial cavity. The two twigs merge to form a single nerve which descends along the internal carotid artery. At the middle of its course the nerve gives off a branch for the superior laryngeal nerve, *IV*, and a little below two or three smaller branches for the internal carotid artery. In its lower part the nerve forms a wide network with terminal ramifications ending in the carotid sinus, *s.c.* Here also terminate single twigs of the glossopharyngeal and vagus nerves (through its pharyngeal branch), both nerves receiving anastomoses from the carotid sinus nerve (*V* in Fig. 2). At the place of bifurcation of the common carotid artery the carotid sinus nerve breaks up into small twigs which participate in the formation of the sinus carotid plexus. To demonstrate the connection between the carotid sinus nerve and the intercarotid ganglion (carotid body) and the upper cervical sympathetic ganglion it was necessary to cut the internal carotid artery and turn the segments upward and downward (*XX*. in Fig. 3). After the carotid sinus nerve has given off a branch (*VI* in Fig. 3) to the superior cervical sympathetic ganglion (*c.s.g.*), it descends to the bulbus caroticus where it divides into two thin branches envel-

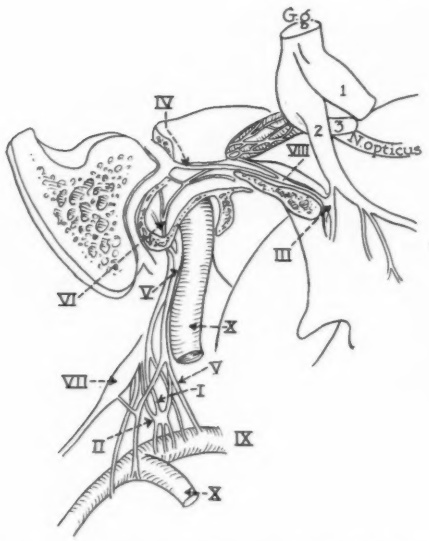

Fig. 5. The drawing illustrates the relationship between the carotid sinus nerve, *I*, carotid body, *II*, and sphenopalatine ganglion, *III*. *IV*, Larger superficial petrosal nerve; *V*, glossopharyngeal nerve; *VI*, tympanic nerve; *VII*, superior sympathetic cervical ganglion; *VIII*, vidian canal; *IX*, external carotid artery; *X*, internal carotid artery; *G.g.*, gasserian ganglion with the three branches (*1*, *2*, *3*).

Fig. 6. The terminal branch of the external carotid, *I*, with its branches; frontal ramus, *II*, and parietal ramus, *III*. *IV*, Terminal ramifications of the zygomaticotemporal nerve.

oping the carotid sinus in the wall of which they are buried. Another branch descends into the intercarotid ganglion at its medial border while at the opposite border one can see the branch connecting the superior cervical sympathetic ganglion with the intercarotid ganglion (Fig. 4).

In other specimens it was possible to demonstrate the connections between the carotid sinus nerve, and the intercarotid ganglion (carotid body) with the vagus as well as with the sphenopalatine ganglion. The sphenopalatine ganglion in its turn is connected with the petrous ganglion of the ninth nerve and through the tympanic nerve or superficial petrosal nerve (minor) with the second branch of the trigeminal nerve. The superficial petrosal nerve (minor) is connected with the otic ganglion situated on the mesial surface of the third trigeminal nerve.

On the basis of our investigations we established the fact that the carotid sinus nerve arises, as a rule, from the main trunk of the glossopharyngeal nerve, usually with one, sometimes with two, branches. In its course this nerve gives off numerous branches, especially from its lower half, which join the main vagus trunk or its lower pharyngeal branches and also twigs from the upper cervical sympathetic ganglion. A small number participate in the formation of the plexus which surrounds and follows the internal carotid artery, while another part ends in the carotid sinus. The branches descending on its dorsal surface belong to the superior laryngeal nerve. The carotid body (intercarotid ganglion) which, as has been emphasized, is situated at the bifurcation of the common carotid artery can always be found in the tissues of a fresh cadaver. For this purpose it is necessary to turn down the trunk of the common carotid artery and sometimes to push the main carotid branches sidewise and carefully to dissect the tissues under falling drops of water. The form of the carotid body varies; it is oval or may appear as a small ganglion with irregular borders; sometimes it is spider-like, provided with numerous nerve branches. Its size varies from a relatively large pinhead to that of a cherry pit. To render more visible the connections of the carotid body with different nerves, it is necessary to shift the blood vessels. Then it is

possible to detect that the carotid body is connected with the carotid sinus nerve, either directly or indirectly, through nerves with which it forms anastomoses (pharyngeal branch of the vagus nerve, a branch of the glossopharyngeal nerve, a large nerve bundle from the cervical sympathetic ganglion, the superior laryngeal nerve, and a branch from ramus descendens n. hypoglossi). The most constant branches come from sympathetic, glossopharyngeal, and vagal nerve branches.

Figure 5 demonstrates the anatomic connections of the carotid body with the ganglia of the second and third trigeminal branches. Clinical observations of the carotid-temporal-neuralgic syndrome made it necessary, as has been mentioned, to study in fresh cadavers with the method of Worobiew the corresponding areas of the temporal region, notably its vascular and nerve supplies. I could demonstrate the terminal divisions of the second trigeminal branch, the zygomaticotemporal rami. These nerves are constant and coincide anatomically with the distribution of the frontal branch of the superficial temporal artery (Fig. 6). It was also possible to establish a relationship between the terminal branch of the external carotid and the auriculotemporal branch of third division of fifth nerve. Two branches of this nerve surround the blood vessel at joint end of mandible and, without giving off branches, run upward.

Our preparations thus enabled us to establish definitely that the terminal branches of zygomaticotemporal ramus belong only to the vascular territory supplied by the frontal branch of the terminal branch of the external carotid, and to prove a relationship of the carotid sinus to the ganglia of one of the cranial nerves.

I believe that these facts may shed some light on the rôle the carotid sinus and carotid body play in normal and pathological conditions.

CONCLUSIONS

1. The carotid sinus nerve arises, as a rule, from the trunk of the glossopharyngeal nerve.

2. This nerve is connected: (a) with the trunk of the vagus nerve; (b) with its pharyngeal branches; (c) with the upper cervical sympathetic ganglion; (d) with the carotid body; and, much more rarely, (e) with the superior laryngeal nerve and the branches of the glossopharyngeal nerve.

3. A small number of the branches enter from above the plexus enveloping the internal carotid artery; some end in the carotid body while others continue on their way down along the common carotid artery.

4. The carotid body is connected with the upper cervical sympathetic ganglion, with the glossopharyngeal nerves, and with the vagal nerves.

5. Jacobson's nerve, n. tympanicus, connects the carotid sinus nerve with the sphenopalatine and otic ganglia.

6. The terminal branches of the zygomaticotemporal ramus (from second trigeminal division) belong to the territory supplied by the frontal branch of the terminal branch of the external carotid.

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RESISTANCE OF PERIPHERAL TISSUES TO ASPHYXIA AT VARIOUS TEMPERATURES

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LIGATIONS OF LIMBS

SEVERAL recent papers (1) have described the effects of the application of tourniquets to the legs of experimental animals. The local effects are reactive hyperemia and inflammation, and paralysis and anesthesia of variable degree and duration, all governed by the length of time of the ligation. Excessively prolonged application of the tourniquet necessarily results in gangrene, from 2 causes; (a) lack of blood supply for a time longer than that for which the tissues can withstand asphyxia; (b) direct pressure effects in the zone of ligation, in the form of ulceration, necrosis, infection and thrombosis, followed by gangrene of the more distal parts. These secondary results of pressure commonly occur sooner than those from the lack of blood supply mentioned under (a); hence, it is not always a simple matter to determine accurately the maximum duration of asphyxia which can be followed by complete and permanent recovery.

The constitutional effect of tourniquet application is a pure and typical form of secondary shock, which has been studied by a series of authors experimentally and clinically. In degree it may range from trivial to fatal. It is governed by 2 factors, namely, the duration of ligation, and the mass and character of the tissue ligated. The time limit of the local resistance to asphyxia, mentioned above, can be learned only by applying the tourniquet to a mass of tissue too small to cause fatal shock even with the longest duration of asphyxia. As the writer has shown, the experimental shock in animals can be standardized by ligating definite portions of the limbs for definite periods. In man, fatal shock is known to result from constriction of the thigh for an uncertain time. The blocking of circulation in the upper arm (for an unknown but obviously long time) has been reported by Cannon as a cause of fatal shock. This is the smallest mass of peripheral tissue which is known to be capable of producing fatal shock by ligation, and by comparison with animals it may be assumed that a tourniquet below the elbow could not give rise to fatal shock regardless of the time.

The activity of tissue metabolism may furnish a reason for difference in the tolerance limits for asphyxia in different species. But when the tourniquet is applied carefully in order to reduce pressure effects to a minimum, the differences between the mammalian species ordinarily used in the laboratory do seem to be extreme. The leg tissues of the rat can tolerate at least 13 hours of circulatory stasis, or possibly more if pressure effects could be further prevented. An experiment published elsewhere (1) illustrated the survival of a dog's leg after stoppage of circulation for 15 hours. Results in the rabbit and cat have been similar. It is not claimed that these periods represent the extreme limit of tolerance. Wilson and Roome found gangrene absent in dogs' legs after complete arrest of blood flow for as long as 20 hours, but the permanency of the survival of tissues was not demonstrated. As the human metabolism is slower than that in the smaller species, the endurance of asphyxia should be fully as long and may perhaps be longer. Cannon's report of fatal shock after 24 hours of compression of a man's thigh between logs made no mention of gangrene, and other instances of prolonged resistance can be found in surgical literature.

On the other hand, inquiry among surgeons reveals a vague belief that a tourniquet may cause sloughing if it stops circulation for more than 3 to 5 hours. This fear may perhaps have its origin in cases complicated with vascular disease, wounds, infections, or gen-

eral weakness. In occasional emergencies the prolonged application of a tourniquet may be compulsory, regardless of the temporary paralysis which follows, and the ability of the tissues to withstand very long asphyxia should be better understood. There is greater danger of constitutional shock, and all possible clinical observations should be collected to establish the length of time required for tourniquets in definite locations to create this danger. It must be remembered incidentally that general weakness from hemorrhage, infection, or any other cause predisposes a patient or animal so powerfully that an otherwise slight shock may prove fatal.

LIGATIONS OF NECK TISSUES

In a series of rats and cats, attempts were made at massive ligations of cervical tissues for periods of 2 to 8 hours. The usual method was to make one vertical incision in the midline and another parallel as far to the side as possible. Blunt dissection was then carried down as deeply as possible, so that finally one elastic ligature applied at the top and another at the bottom produced complete asphyxia of most of the tissue of one side of the neck, consisting of skin, muscles, thyroid, and the jugular veins and contents of the carotid sheath.

No animals died as a direct result of such ligations of the vagus nerve, the jugular veins and the carotid artery, even when the procedure was repeated on the other side of the neck after 2 or 3 weeks. Any cardiac disturbance seemed to be temporary or unimportant. A sympathetic influence was often noticed in abduction of the eyeball, narrowing of the pupil, and contraction of the nictitating membrane. The general plan was spoiled by a difficulty which has been encountered in all parts of the body in rats and which prevailed likewise in the necks of cats. Ligatures applied directly in contact with the tissues, without the protection of intervening skin, tend strongly to obliterate vessels and produce necrosis in the soft tissues of small animals. For this reason only the 2 hour ligations were endured, and it was impossible to learn the true tolerance of the neck tissues for asphyxia. In larger species, such as dogs and man, the vessels are larger and the tissues tougher, so that temporary ligation of the exposed tissues is more feasible. Unfortunately, it was not possible to repeat experiments of this type on larger dogs. Under any conditions, the influence of a wound will be to reduce the resistance to asphyxia.

LIGATIONS OF TONGUE

Light rubber ligatures were placed between 1 and 2 centimeters from the tip of the tongue in a series of dogs and cats, for periods of 4 to 8 hours. Certain special provisions are necessary in such experiments. The tongue must not be allowed to become too dry. Also, it must not be confined too completely within the mouth, where the continuously elevated temperature is unfavorable for survival. It must be guarded against injury by the teeth, not only during the ligation but particularly for a number of days afterward, because the combination of swelling, paralysis, and anesthesia makes it extremely liable to injury, ranging from complete amputation to mere tooth punctures which open the way to infection and gangrene.

These requirements could seldom be fulfilled perfectly, but in successful cases it was proved that the tongue can withstand at least 8 hours of asphyxia. This is logically to be expected, since the organ is composed essentially of mucous membrane and muscles, and has an abundant blood supply. Theoretically, if it could be ligated under strictly the same conditions as the limbs, it should withstand the same duration of asphyxia. In practice, however, aside from the above difficulties, it is probable that the mucous membrane will be less resistant than skin to direct pressure, and that therefore ulceration at the zone of ligation will be more serious and will shorten the time limits.

The local reaction in the tongue is also more intense than that in the limbs, the hyperemia and edema being very great. Under favorable conditions they gradually subside. Also, the complete paralysis which exists after a 4 to 8 hour ligation diminishes in the course of a week or more, with the result that restoration of the function of the tongue becomes complete.

INFLUENCE OF ELEVATED TEMPERATURE

Elevations of only a few degrees of temperature multiply the effect of asphyxia, so that either local gangrene or fatal shock may result within a fraction of the time required at room temperature.

An illustration is furnished by a rat which had one hind leg ligated and immersed in water at 38 to 39 degrees C. for 2 hours. The red cell count rose from 7,500,000 before, to 8,750,000 at the end of ligation, presumably because of warmth and struggling. After release, the hyperemia and swelling were much greater than after a 2 hour ligation at room temperature. Within 1½ hours the rat was in a state of collapse, with red cell count up to 10,750,000. An injection of 2 cubic centimeters of saline was given intravenously, and 20 cubic centimeters in addition was injected into the peritoneum and under the skin. Nevertheless death occurred 45 minutes later, with a red cell count of 10,250,000.

Examples of gangrene which occurred after brief ligation at elevated temperatures are given elsewhere (1).

It may be difficult to convince clinicians that such severe injury to bloodless parts is produced by temperatures which feel merely lukewarm to the hand and which are well within the range of fever which can be tolerated almost indefinitely when circulation is present. The erroneous ideas and exaggerated fears of surgeons in regard to the tourniquet may be based not only upon the complications mentioned above, but still more upon the vicious and indefensible practice of artificially warming limbs which lack circulation. If a bare minimum of blood supply is present, the dilation of blood vessels with heat gives a rational promise of benefit. But in borderline cases, it must be questioned whether this will compensate for the increase of local metabolism, with the resultant demand for an increased supply of oxygen and food materials and an increased removal of carbon dioxide and waste products. Beyond this point, when the blood supply is either absent or obviously deficient, the use of any warmth whatever only invites and hastens disaster. Because of these experimental and clinical facts, the indiscriminate use of heat for diabetic gangrene should be replaced by a very guarded and selective use. Some surgeons already avoid its use in embolism and similar conditions, but the principle seems to be not generally understood and heeded.

INFLUENCE OF REDUCED TEMPERATURE

Reductions of the temperature of a ligated limb correspondingly reduce the local metabolism and the danger of both gangrene and shock. It is obviously necessary to avoid the destructive effect of freezing; but short of this, the lower the temperature the longer is the time for which lack of circulation can be safely tolerated.

SHOCK

Previous papers have shown that at room temperature fatal shock results from the ligation of one hind leg of a rat for 5 hours, or from blocking of the aorta by abdominal ligation for 1½ to 2 hours. The following experiments illustrate the influence of temperature of about 2 degrees C.

A strong rat weighing 140 grams had one hind leg ligated in ice water for 5 hours. After release the leg flushed a pale pink, but the usual intense hyperemia, local swelling, and systemic weakness were practically absent. The initial red cell count of 7,260,000 was scarcely changed during the entire observation, the highest count being only 7,600,000. Because of imperfect protection of the body the rectal temperature fell very low (28 degrees C. minimum); nevertheless the animal recovered easily and completely. On the other hand, in ordinary shock experiments, although comfortable warmth is beneficial, artificial elevation of the body temperature does not save life.

Another very strong male rat had the abdomen ligated for 3 hours. The legs and body (including large testes) posterior to the ligature were immersed in ice water throughout the 3 hours, while the anterior part of the body was artificially warmed. On release of the ligature the rat was placed in a warm chamber, but nevertheless shivered as the circulation returned in the chilled parts, and 30 minutes after release the rectal temperature was 27 degrees C. There was only slight weakness, and slight hyperemia and edema in

the paralyzed hind parts (in which, however, sensation was retained, contrary to the rule at room temperature). The rectal temperature gradually rose, but was only 32 degrees C. 3½ hours after release. The rat remained alert, reacting normally to the environment; it drank 1 or 2 cubic centimeters of water, and no fluid was injected. The red cell count was 7,300,000 before ligation. At the end of ligation, just before release of the ligature, it had risen to 9,100,000. After 30 minutes it was 8,900,000, and after 3½ hours it was 8,370,000. The corresponding leucocyte counts were irregular, viz., 32,750, 21,300, 28,250, and 43,650. The rat survived in strong condition, until the usual bladder obstruction brought death 1 week later from hydronephrosis.

LOCAL TISSUE SURVIVAL

Larger species were used instead of rats for the longest experiments, because of the better tolerance of changed temperatures, abstinence from food, and general strain. Light amytal narcosis was used at the beginning in all cases, until the animal became accustomed to the confinement, after which it could be largely or entirely omitted. The leg was passed through a suitable opening in the animal board, for immersion in ice water to a level 1 or 2 centimeters above the ligature. The body of the animal above the board was kept dry, and was wrapped warmly in blankets or heated electrically. Constant day-and-night watching was necessary. By padding and other devices the animals were kept comfortable though immobile, and their position was changed several times in each 24 hours as a precaution against either discomfort or circulatory disturbances. Immediately after release the ligated leg was dried with a towel and the animal placed near a steam radiator or in a heated box.

Rabbit 1. The left hind leg was ligated about midway between the knee and ankle and immersed in ice water for 30 hours. The rectal temperature fell within the first 3 hours to 28 degrees C., and afterward with better heating was kept between 33 and 35 degrees C. On release the rabbit was strong, and drank water immediately. The ligated part showed the light pink color which is usual after refrigeration, but warmth returned only gradually, and slight edema was 2 to 3 hours in developing. Sensation in the foot seemed to be regained in 4 days, and after 8 days the motor paralysis had cleared up.

Rabbit 2. The right hind leg was ligated about midway between the knee and ankle and immersed in ice water for 52½ hours. The rectal temperature was frequently down to 34 or 35 degrees C. occasionally up to 37 degrees C. Injections totaling 50 cubic centimeters of saline were given subcutaneously. Upon release, the ligated leg was paralyzed and required about an hour to become warm. Edema was most marked at and above the zone of ligation, comparatively slight below. The rabbit remained well and strong. There was no ulceration, and the local swelling and paralysis cleared up in about 1 week.

Cat 1. The right hind leg was ligated about midthigh and immersed in ice water for 28 hours. The rectal temperature remained mostly between 32 and 34 degrees C. After release the circulation returned rapidly and the cat shivered violently even in a heated box. Stupor was due only slightly to amytal, mostly to collapse. Edema gradually developed about the zone of ligation but was slight below it. One hour after release, 200 cubic centimeters of saline was injected subcutaneously; and about 45 minutes later 150 cubic centimeters was injected under the skin and 100 cubic centimeters into the peritoneum. The collapsed state persisted unchanged; the heart was weak but not excessively fast, and the respirations were strong and regular without dyspnea. No notice was taken when the jugular vein was exposed 2¼ hours after release and 100 cubic centimeters of saline injected into it. The strength of the animal continued to fail, and death occurred 7 hours after release. The rectal temperature rose to 39 degrees C. and the tissues felt hot at autopsy.

The heart was found contracted but the great veins were well filled. The viscera were negative. The bladder contained a considerable amount of pale urine; the ligated leg was hyperemic, very slightly edematous, with liquid blood in patent vessels and no sign of necrosis or thrombosis.

Blood counts were taken before application of the tourniquet, immediately before its release, at 1 hour after release (immediately before the subcutaneous saline injection), also 2¼ hours after release (immediately before the intravenous saline injection), also 1 hour after that, and finally at autopsy. All the counts during life were easily obtained from the ear, indicating sustained peripheral circulation and adequately filled vessels. The red cell counts in this order were in millions 8.1, 10.7, 11.8, 7.6, and 6.6. The corresponding leucocyte counts in thousands were 9.7, 18.5, 16.0, 10.0, and 9.2.

Cat 2. The right hind leg was ligated about midthigh and immersed in ice water. The rectal temperature remained at about 33 degrees C. After 49 hours a new ligature was applied below the knee, then the first one was removed, and the ice water was lowered so as to stand 1 to 2 centimeters above

the new ligature. This ligature was removed 11 hours later (making 60 hours of asphyxia for the tissues below it). The purpose of this procedure was to subject a limited mass of thigh tissue to asphyxia for a time which it was hoped might be endurable, if circulation was allowed to return only in this limited mass and was blocked from the lower leg by a new ligature. The hope was that the animal might be able to overcome this degree of intoxication within 11 hours; then the ligature below the knee could be released, because a 60 hour ligation at this point does not produce fatal shock in normal animals.

A subcutaneous injection of 100 cubic centimeters of saline was given 1½ hours after release of the first tourniquet, and again after 7 hours. Nevertheless, the cat weakened progressively and at the time of release of the second ligature was already unconscious, with feeble pulse and rapid shallow respiration. An additional 200 cubic centimeters of saline was injected subcutaneously at this time, and repeated 2 hours later. Death occurred 3 hours after release of the second and 14 hours after release of the first ligature. The rectal temperature rose to 38 degrees C. 1 hour before death.

Blood counts were easily obtained from the ear shortly after the application of the first ligature, just before its release, 1¼ hours after its release, also just before and 1¼ hours after release of the second ligature. The red cell counts in this sequence were as follows, in millions: 9.2, 10.3, 11.3, 11.9, and 13.5. The corresponding leucocyte counts, in thousands, were 23.5, 27.5, 22.7, 18.0, and 16.6.

At autopsy the heart and great veins were fairly well filled, the lungs congested. The viscera were negative. The greater part of the injected fluid remained under the skin. The tissues between the upper and lower ligatures appeared practically normal, with only slight congestion and edema. The leg below the lower ligature was slightly darker, but the vessels were patent and contained liquid blood, not clots. The circulation in it was evidently not as active as usual because of the extreme prostration, but there was no appearance of gangrene.

In this experiment, subcutaneous saline injections were ineffectual for preventing a marked concentration of blood as indicated by the rising red cell counts. The other symptoms were those typical of shock, except for the slight fever in contrast to the usual subnormal temperature. The edema of the ligated parts was so slight that the discharge of blood plasma must have occurred chiefly into the general body tissues. These experiments agree with the results of the shorter ligations at room temperature, in apparently necessitating the assumption of a chemical substance from the ligated tissues.

The reason for the dangers of thigh ligations have been explained elsewhere, being due chiefly to large masses of deep tissue which are inadequately chilled with the method used.

Cat 3. A tourniquet was applied near the left ankle and the foot immersed in ice water for 54 hours. With blanket coverings the rectal temperature within the first 12 hours fell to as low as 30 degrees C., but under electric heat it was afterward kept between 33 and 35 degrees C. Because of the rise of the red cell count during ligation, 200 cubic centimeters of saline was injected subcutaneously shortly before release of the tourniquet. The cat retained good strength and recovered uneventfully. The ligated foot swelled to about twice its normal size, but ulceration was limited to a part of the skin which suffered from direct pressure in the ligation, and aside from temporary paralysis there was no disability in the foot below the ligature.

Blood counts were taken before the application of the tourniquet, 2 hours before release, 5 hours and 14 hours after release. The red cell counts in this order, in millions, were 7.8, 11.3, 11.7, and 7.8. The corresponding leucocyte counts were, in thousands, 23.1, 18.7, 10.8, and 14.5.

As fasting cats exhibit no marked thirst or desiccation in the course of several days, and this cat drank only a trifle after release, the concentration of blood under the conditions of ligation was probably related to shock. After release there was an intense local reaction in the ligated part, but the mass of tissue was too small to give rise to any dangerous constitutional effects.

A dog, weighing 10 kilograms, underwent ligation of the right hind leg in the lower third of the thigh, with immersion in ice water for 24 hours. The rectal temperature was found once down to 32 degrees C., but mostly was kept at 34 to 35 degrees C. Twice during ligation the dog drank thirstily and thus evidently prevented concentration of the blood. Nevertheless he was very weak and listless after release, perhaps from simple exhaustion; he drank water repeatedly but refused food until 24 hours after release. During this time the rectal temperature remained at 34 degrees C.

Though the tourniquet had embedded itself deeply in the tissues, the circulation returned promptly, so that the leg was warm to the toes within 5 to 10 minutes. The dog then showed signs of pain (which is not indicated in most animals). Hard inflammatory swelling developed at the zone of ligation, but edema in the leg below it was very slight. Paralysis and anesthesia were complete.

Blood counts were taken immediately after application of the tourniquet, immediately before its release, at the depth of prostration 1 hour after release, and in the stage of recovery 7 hours after release; also 3 days later. The red cell counts, in millions, were serially as follows: 7.25, 7.5, 6.98, 5.7, and 5.0. The corresponding leucocyte counts were, in thousands, 12.25, 30.0, 26.5, 14.3, and 20.0.

Paralysis, anesthesia, hyperemia and slight edema, without ulceration or necrosis, persisted in the ligated part of the leg. All these diminished during several days, except the paralysis. After 5 days the dog could evidently feel pin pricks in the lower leg, but there was the usual longer delay in motor recovery, so that complete use of the leg was regained only after 10 days.

SUMMARY AND CONCLUSIONS

1. The period for which peripheral tissues can survive when the blood supply is stopped by a tight tourniquet at room temperature is found experimentally to be as follows: for the legs of rats, rabbits, cats, and dogs, 13 to 15 hours or longer; for the tongue in cats and dogs, 8 hours or longer; for the neck tissues in rats and cats, only 2 hours, because of the complicating influence of the wound and tourniquet pressure on the exposed tissues especially in small species.

2. Slight elevations of temperature (within ordinary febrile limits, or to a degree which feels only comfortably warm to the hand) multiply the effects, so that local gangrene or fatal shock may develop after only a fraction of the time of ligation that is tolerated at room temperature.

3. Reductions of temperature greatly reduce the dangers of ligation as regards both gangrene and shock. Whenever the temperature can be efficiently maintained at about 2 degrees C., the limbs can survive asphyxia for a long period, the maximum of which has not been accurately established but which is certainly more than 50 hours.

4. The experiments with elevated temperature warn against the indiscriminate use of artificial heat in conditions of local anemia. It is hoped that the experiments with reduced temperature will find some clinical applications.

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THE PATHOLOGIC BASIS FOR SWELLING OF THE ARM FOLLOWING RADICAL AMPUTATION OF THE BREAST

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THE most serious postoperative complication of radical breast amputation, regardless of the type of incision, is swelling of the arm. The swelling may be of a brawny type with evident thickening of the skin, or it may be of the soft type with thin, shiny skin. There is a wide variation as to the time of onset of this complication. It occasionally occurs in patients with malignancy of the breast even before surgical interference, but is rare during the immediate postoperative convalescence period. In the majority of cases it occurs between the third and sixth month after operation, but in a few it will not be noted for even a year or longer. Concomitant with the onset of the swelling there is often some evidence of a recurrence of the malignancy. There may be a mass in the axilla, an enlargement of cervical lymph glands, or a nodule in the scar. There may be pulmonary symptoms, such as cough, pain in the chest, or hemoptysis. In some a definite history of recurrent lymphangitis or cellulitis preceding the onset of the edema may be obtained. In still another group the swelling will be found to be coincident with the return to normal activity and the use of the arm in arduous tasks. Finally, this complication may occur without any premonitory signs or symptoms. Once the swelling occurs, it may be persistent and progressive, until the extremity becomes enormous in size. It may be intermittent in character, swelling during the period of activity and dependency of the arm, and subsiding during rest and elevation. It may progress to a certain stage and remain stationary, not being affected by activity, dependency, rest, or elevation of the limb. Usually the entire extremity is enlarged, but in some the posterior portion of the upper arm is involved out of proportion to the other parts. There is usually some disability of the limb and this may progress to complete incapacitation. Pain is a common symptom accompanying the swelling. It may be due to the increased tension of the edematous tissues, or it may follow direct involvement of the brachial plexus.

From the wide variation of clinical signs and symptoms it is evident that there are several types of swelling of the arm following radical removal of the breast. Furthermore, all of these types cannot be explained on a single pathologic basis. It has long been recognized that the swelling may be caused by lymphatic blockage or venous obstruction. The experimental work of Halsted and his associates, Reichert and Bidgood, demonstrated to their satisfaction the importance of lymphatic obstruction in the production of the edema. Halsted concluded that infection of the operative field leads to recurrent lymphangitis and lymphatic obstruction which resulted in swelling of the arm. To this condition he applied the term "elephantiasis chirurgica." This excellent study provided an explanation for one form of postoperative swelling of the arm. It has been generally accepted as the cause for all cases and the rôle of venous obstruction has received little attention.

There is a striking difference between the edema of pure lymphatic blockage and that produced by venous obstruction. However, it is difficult, particularly in the chronic stages, to differentiate between these forms by clinical observation alone. Vasography or the direct visualization of the vessels in the living subject, has provided a new approach to the study of the pathology of the peripheral blood vessels. After the injection of an opaque medium into either the arterial or venous systems of an extremity these vessels can be visualized in the x-ray. By applying this method of study to the venous system of the upper ex-

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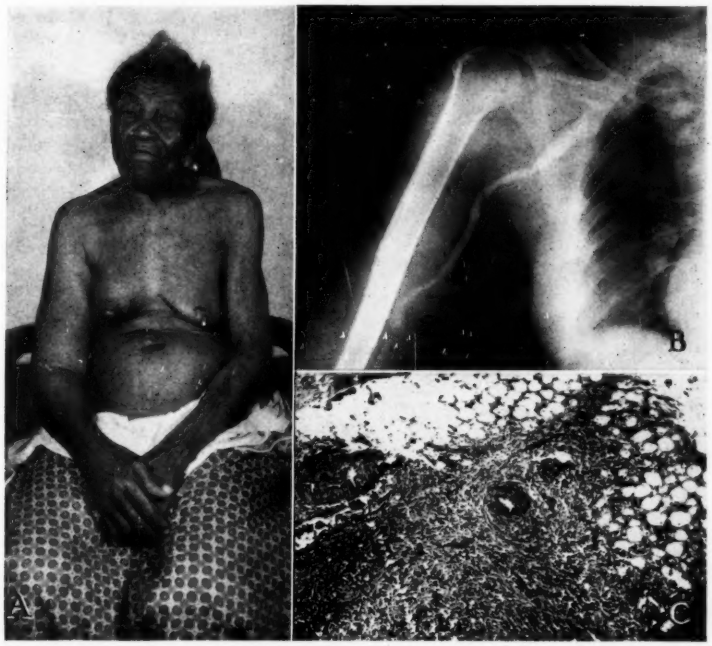

Fig. 1. Primary lymphatic edema. A, Photograph showing pre-operative brawny edema of right arm. B, Venograph showing axillary vein intact. C, Low power photomicrograph showing invasion of carcinoma into subcutaneous tissue of arm (section taken from elbow region).

tremity in postoperative swellings of the arm, one can determine the presence or absence of venous obstruction. When supplemented by venous pressure studies one can ascertain the rôle of venous occlusion in the production of the edema.

In a recent communication we reported the venographic findings in 20 cases of swelling of the arm following radical removal of the breast. From these observations we classified the cases according to the primary cause of the edema into: (1) lymphatic obstruction, (2) venous obstruction, and (3) lymphatic and venous obstruction. Since that publication we have had the opportunity of studying 26 additional patients, or a total of 46 cases of swelling following operation. Twenty-two patients who did not experience swelling of the arm after operation have been studied in order to determine the possible extent of venous obstruction that may exist before edema occurs. We have also supplemented the venographic studies with venous pressure determinations in a series of cases as a confirmatory test. These studies have proved valuable as a means of differentiating between the several forms of swelling of the arm following radical breast amputation. Furthermore, we are now able to draw more definite conclusions as to the pathologic basis for the three types of postoperative edema, namely, lymphatic edema, venous edema, and lymphatico-venous edema.

LYMPHATIC EDEMA

Pure lymphatic edema is of a brawny, persistent type, which is only partially reduced by rest and elevation of the arm. The skin is firm and pits slightly on pressure, but does not wrinkle in the pit. It is the least common form of edema of the arm following radical removal of the breast.

Fig. 2. A, Recurrent carcinoma with massive swelling of the entire arm. B, Venograph showing complete obstruction of basilic, axillary, and subclavian veins (proved by autopsy). Only cephalic vein remains. Collaterals are developing over shoulder. Venous pressure, 75 centimeters of water. C, Section of subclavian vein showing occluding thrombosis.

In our series the swelling in approximately 10 per cent of the cases was due primarily to lymphatic obstruction. It is necessary to block both the superficial and deep lymphatic systems of the arm to produce edema. The lymph circulation of the arm is readily readjusted after simple removal of the axillary lymph glands. Sufficient lymphatic obstruction to cause edema of the arm may result from recurrent or persistent infection of the soft tissues of the upper arm, axilla, and shoulder. The source of the infection may be from the fresh operative field, from open injury to the healed scar, or from recurrent carcinoma with ulceration on the skin surface. These patients frequently present a history of recurrent lymphangitis or cellulitis of the arm and shoulder. The infection may be accompanied by chills and fever, and pain in the arm, neck, and shoulder. The cervical lymph glands often become enlarged, tender, and painful during the period of active lymphangitis. Swelling of the arm is likely to occur with the initial attack, but may disappear as the infection subsides. After recurrent attacks the edema becomes persistent and is little affected by rest or elevation of the arm. The direct extension of the carcinoma into the skin and subcutaneous tissue of the arm may lead to sufficient blockage of the lymphatics to produce edema, but this form of lymphatic obstruction is not as frequent as the inflammatory form. Such an example is shown in Figure 1. The scarring of the tissues of the thorax, the axilla, and the shoulder from the operation, plays a minor rôle, if any, in the production of this form of edema.

The venographic findings in the pure lymphatic edema cases show that there is no obstruction of the large venous trunks. There is no evidence of collateral venous circulation nor is there any abnormal elevation of the local venous pressure. The swelling may com-

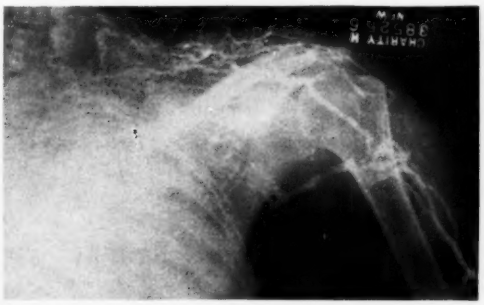

Fig. 3. Postoperative venous edema. Recurrent carcinoma. Venograph shows complete occlusion of axillary and subclavian veins. Venous pressure 140 centimeters of water in affected arm, and only 10 centimeters in the normal arm. Note soft pitting edema of hand.

press the small tributaries but the large venous trunks remain intact and therefore the venous pressure will not be materially affected.

EDEMA FROM VENOUS OBSTRUCTION

The edema produced by venous obstruction is of the soft, pitting type. The skin is thin and tense and there is wrinkling of the pitted portion. Approximately 90 per cent of the cases of edema of the arm following operation are due primarily to venous obstruction. After the edema occurs there is a retardation of lymph flow with changes in the lymph vessels. If the edema is not soon relieved there is increasing evidence of lymphatic obstruction. These cases then gradually merge into the lymphatico-venous type which will be discussed later. Those cases resulting from venous obstruction that have maintained the soft, thin, shiny skin, which pits deeply on pressure have been classified as the simple venous type. Those cases resulting from venous occlusion, which has been followed by sufficient lymphatic obstruction to produce the characteristic thickening of the skin, have been classified as the lymphatico-venous type of edema. In the simple venous edema group, the effect of rest and elevation of the arm varies according to the extent of the obstruction and the height of the local venous pressure. In mild degrees of occlusion the edema may temporarily disappear by rest and elevation of the arm, but with very extensive venous obstruction this measure is not likely to bring any relief.

Simple ligation of the axillary vein at one point apparently will not produce edema, provided sufficient tributaries are left intact. Sudden occlusion of the axillary and subclavian veins by a thrombus produces massive edema of the entire arm and hand. This has been repeatedly shown in cases of primary thrombophlebitis and in the so called effort thrombosis. In these cases the edema disappears within a few days to several weeks. The disappearance of the edema is due to the development of a collateral venous circulation. From a study of 6 cases of primary axillary and subclavian vein thrombosis by means of venography we have found that collaterals develop rapidly, because the tributaries are intact and the tissues through which they run are soft and pliable. The important tributaries taking part in the development of the collaterals are the superficial system over the anterior shoulder and chest, the veins following the thoraco-acromial artery, the long thoracic, and the cephalic vein. In some

Fig. 4. Complete occlusion of axillary vein by benign scar formation. Edema developed about 2 months following operation and has persisted for 5 years. No evidence of recurrence of malignancy. Arrow indicates point of venous occlusion.

cases there is a recanalization of the axillary and subclavian veins. Apparently the veins in the scapular region take little part in the development of collateral vessels.

Obstruction of the axillary or subclavian vein following radical breast amputation may cause more serious consequences because certain obstacles interfere with the development of collateral vessels. The operation lays the foundation for the prevention of the formation of collateral venous circulation. Radical breast amputation implies the complete excision of the breast, the pectoral muscles, and the removal of all regional lymphatics. Therefore, certain important venous tributaries are always sacrificed. Those vessels supplying the pectoral muscles, of course, are destroyed and the superficial vessels over the anterior axillary fold and breast region are divided. Often the long thoracic vein must be sacrificed, and occasionally the cephalic vein is divided. Even with such extensive dissection the venous return usually readily compensates and edema is seldom an immediate complication. It is not the actual sacrifice of venous tributaries at the time of operation but the later scarring of the tissue with further venous obstruction that is important in the production of edema. Let me repeat, the operation lays the foundation for preventing the development of adequate collaterals. The late scarring or recurrence of the malignancy produces the actual constriction or obstruction of the large vessels that leads to increased venous pressure and edema.

By far the most common cause of venous obstruction is a recurrence of, or better, a continuous spread of the breast malignancy to the axillary and subclavian veins. The new growth may simply compress one or both of these veins. A small nodule is sufficient to cause complete obstruction, especially when the arm hangs by the side, because of the unyielding scar tissue resulting from the operation. The tumor growth may encircle and cause a strangulation of the large venous trunks in the axilla or it may spread along the subclavian vein and constrict it. In some cases the spread of the carcinoma may be from within the chest and produce an obstruction of the subclavian vein. By compressing the large trunks the venous flow may be so slowed that thrombosis results and thereby produces a complete and widespread occlusion (Figs. 2 and 3). The tumor cells may infiltrate the vein wall and produce sufficient irritation of the intima to cause a thrombosis, or they may actually invade the vein and produce complete obstruction by filling the lumen with the new growth.

The axillary vein may be constricted or completely occluded by benign scar tissue (Fig. 4). This may occur within a few weeks or may not occur for several months or even a year following the operation. The most common incision followed by scarring sufficient to obstruct the axillary vein, of course, is the one in which the axilla is actually involved. The original incision may seem sufficiently removed from the axilla, but on contraction may actually fall in it. The scar may then incarcerate the vein or may cause obstruction when the arm hangs by the side because of its unyielding nature. Scars from incisions that do not directly involve the

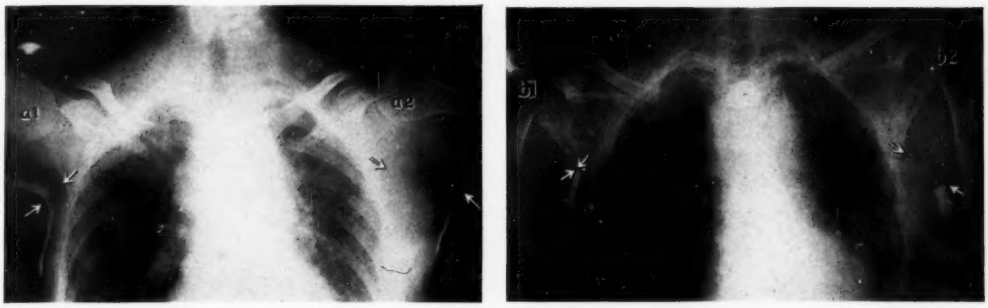

Fig. 5. A, left, X-ray of chest with arms extended to right angle position. Skin of floor of axilla covered with barium to render it opaque. *a1*, Axilla of side on which a radical breast amputation has been performed. Arrows indicate depth of axilla. *a2*, Normal axilla. Note depth of axilla as indicated by arrows. B, Same case with arms by side. *b1*, Side operated upon, showing fixation of floor of axilla. Note the narrow space between arrows. *b2*, Normal side showing shift of floor of axilla downward and depth of axilla.

axilla may so narrow this space that the veins become constricted, especially when the arm is dependent. In the normal subject there is a considerable shift in the position of the axillary vein when the arm is moved from an angle of 90 degrees to complete adduction (arm by side). The vein moves downward with the pectoral muscles and the floor of the axilla, from a straight course to an obtuse angle (Fig. 5). Radical breast amputation produces a narrow and shallow axilla and the skin of the floor becomes partially or completely fixed to the chest wall, so that when the arm is brought to the side the vein may not form an obtuse angle but an acute one, even to the point of complete occlusion (Fig. 6). This is the position in which the arm is held the greater part of the time and it may be permanently fixed in this position by scar tissue extending from the upper arm to the chest wall. Occasionally the development of a large fat fold in the axilla will cause obstruction of the axillary vein when the arm is dependent.

As the main venous trunks become constricted or completely obstructed by any of the methods mentioned, the blood attempts to find other pathways. The operation by its nature has removed many of the tributaries, and the extensive scar has blotted out the important superficial routes. The result is inadequate collateral formation, increased venous pressure, and finally edema and swelling of the extremity. Venographic studies in these cases will reveal the site of obstruction of the axillary or subclavian veins, the back flow of the opaque medium into the tributaries, and the development of new venous channels. When the obstruction lies proximal to the entrance of the external jugular vein into the subclavian vein the actual point of occlusion may not be visualized, but the back flow into the tributaries and collaterals will be shown. In such cases venous pressure determinations become invaluable. The normal venous pressure in the arm at heart level ranges up to 12 centimeters of water. Krogh et al. found that in normal subjects fluid was filtered into the tissues of the forearm when the venous pressure exceeded 15 centimeters of water. Above an average venous pressure of 17 centimeters of water the rate of filtration was directly proportional to the increase in venous pressure. However, there may be no clinical evidence of edema until the venous pressure is much higher. We have seen cases in which the venous pressure was persistently as high as 25 centimeters of water before pitting edema occurred. In our series of patients who did not experience edema following operation and on whom venous pressures were recorded, there was no abnormal elevation of the pressure. In those patients who suffered edema and who showed evidence of venous obstruction, the pressures have ranged from 19.5 to 140 centimeters of water, the average being 53 centimeters of water. Generally speaking, as the degree of venous

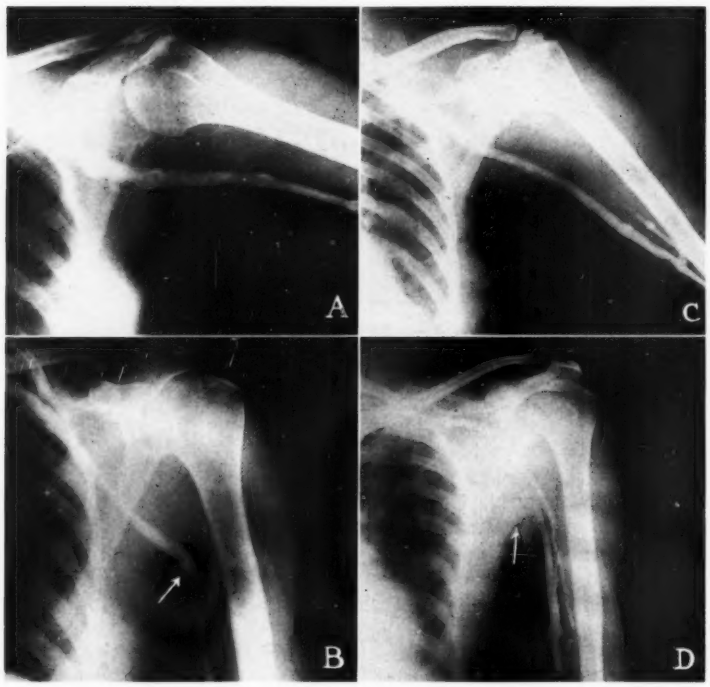

Fig. 6. A, Venograph showing normal axillary vein with arm extended. B, Venograph of same patient with arm by side. Note obtuse angulation of axillary vein as indicated by arrow. C, Venograph of axillary vein in patient who develops edema of the arm only when the arm is dependent. Note that with arm extended the vein is not occluded. D, Venograph of same patient with arm by side. Note complete occlusion of axillary vein (arrow) and backflow of opaque medium into the tributaries.

obstruction increased there was a concomitant rise in the local venous pressure and a greater increase in the edema of the arm.

EDEMA FROM LYMPHATICO-VENOUS OBSTRUCTION

This form of edema is characterized by thickening of the skin with pitting edema that is only slightly affected by rest and elevation of the extremity. Recently McMaster has made some valuable contributions on the cutaneous lymphatic circulation. By injecting patent blue V′, a vital dye, intradermally the cutaneous lymphatics were rendered visible and then by making serial photographs of these injected vessels he was able to record the actual changes that occurred in the lymphatics under normal and pathological conditions. In this study he made two observations that seem to have some direct bearing on the mechanism of the development of postoperative lymphatico-venous edema of the arm. He found that in the intact, resting, dependent limb lymph does not flow in the cutaneous lymphatics. He also showed that in cardiac edema the cutaneous lymphatics were extremely dilated, that the valvular system was incompetent, and that the lymph flow had ceased. The edema resulting from simple mechanical venous obstruction is similar to cardiac edema both physically and chemically, and in the manner in which it is produced. Therefore it seems logical to assume that in edema of the arm resulting from venous obstruction the lymphatic circulation undergoes the same changes as occur in car-

Fig. 7. Lymphatico-venous edema. Primary obstruction of axillary vein. Secondary lymphatic stasis. Recurrent cellulitis and lymphangitis.

diac edema. Accepting this assumption, the first step then in the production of the lymphatico-venous type of edema is obstruction of the venous system by one of the methods mentioned above. The obstruction of the large veins causes an increase in the local venous pressure and because of the lack of adequate collateral pathways, this pressure is maintained and edema results. Once the edema has occurred there is a dilatation of the lymphatics, an incompetency of its valvular system, and a cessation of the cutaneous lymph flow. Dependency of the arm, the position in which it is held most of the day, acts to maintain the elevated venous pressure and prevent any emptying of the lymphatics. If these conditions are not soon relieved, the skin takes on the characteristic thickened and coarse appearance. We then have a condition similar to the "milk leg" which follows thrombosis of the deep veins of the thigh and pelvis. Infection is prone to develop after lymphatic and venous obstruction, and it may be the cause of further lymphatic blockage as well as an increase in the swelling (Fig. 7).

The venographic studies and venous pressure determinations reveal the same findings as those found in the group presenting simple venous edema.

SUMMARY

Simple lymphatic edema is the least frequent cause of swelling of the arm after radical breast amputation. This form of edema may result from recurrent lymphangitis, cellulitis, or skin metastases. The deep veins of the arm are not primarily involved and remain patent.

Edema resulting from obstruction of the axillary and subclavian veins is by far the most common cause of swelling of the arm following operation. The most frequent cause of the venous obstruction is a recurrence of the malignancy along the course of these veins. In some cases the venous occlusion results from benign scar formation. In others the axillary vein is occluded by the sharp angulation of its course when the arm is dependent because of the fixation of the floor of the axilla. The venous obstruction produces a local increase in the venous pressure and fluid escapes into the tissues. Lymphatic stasis is a secondary result of the venous obstruction and if prolonged will lead to permanent blockage of the lymphatic flow. Infection is prone to develop and may lead to further obstruction and cause a greater degree of swelling. The skin may then become thickened and present the typical picture of lymphatic edema.

A carefully taken history and a thorough examination will give valuable information regarding the cause of the lymphatic or venous obstruction. Venographic studies and local venous pressure determinations will be of value in ascertaining the rôle of venous obstruction as a causative factor in the production of the edema.

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CLINICAL SURGERY

FROM THE DEPARTMENT OF SURGERY, UNIVERSITY OF KANSAS SCHOOL OF MEDICINE

TOTAL RECONSTRUCTION OF THE AURICLE

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IN SO FAR as the individual with a major deformity of the auricle is concerned, the reasons for its reconstruction may be threefold: (1) To promote economic efficiency, (2) to alleviate a psychiatric defect, and (3) to give personal satisfaction. The prejudiced attitude of employers and associates often promotes an economic impasse. Whipping the defense reaction against the onslaught of a cruel environment is not a pleasurable pastime even if one is capable of such a reaction. But if one be so unfortunate as to fail in readjustment and the negative surmounts the positive ego, inadequacy to environment follows. The knowledge that one is presentable socially may be a great boon to a sensitive, tried, and sore spirit. Therefore, it can not be said that an adequate procedure which tends to abrogate these reactions, even without other objectives, does not entail in its accomplishment a beneficent craft.

Besides making a report on 4 total reconstructions of the auricle, 1 of which has been observed for 10 years, I wish herein to present a plan for the reconstruction of the external ear which may be performed with safety for the patient in 3 operative sittings with a total hospitalization period of less than 3 weeks. The hospitalization period should be about 1 week for the first stage. After this, an interval of about 2 months should supervene before the second stage. The second operation should keep the patient in the hospital less than 1 week if all goes well. Finally, after an interval of a month, or more if desirable, the third operation is performed. The hospitalization period following the third stage should not be more than 4 days. Any slight subsequent trimming operations can be carried out at the outpatient department of the hospital or at the office, depending upon preference or facilities.

Probably all reconstructive surgeons will readily admit that the problem of reconstructing the auricle is one to try the ultimate skill and technique of the surgeon. In 1919, J. S. Davis expressed the opinion that "the possibility of successful plastic reconstruction is doubtful and at best the cosmetic results are only fair." In 1929, A. D. Davis remarked that "many attempts at correction have resulted in an end result that looked more like a cabbage than an ear." Lockwood (1929) commented that "the most difficult feat in plastic surgery is reconstruction of the congenitally absent ear." J. C. Beck, in 1930, stated that "the great difficulty is to obtain a good cosmetic result when the external ear is more than two-thirds absent. Surgery, however, has not proved equal to the task. The long, tedious, multiple procedures do not produce results that are esthetically acceptable and only serve to substitute monstrosity for deformity." As late as 1937 Gillies observed that "The study of one's own and other surgeon's actual results reveals an undisputed disappointment in the cosmetic results obtained by these methods."

Within the past decade A. D. Davis (1929), Lockwood (1929), Beck (1930), Pierce (1930), New (1931), Bettman (1934), Eitner (1934), Gillies (1937), and others have presented cases and methods for reconstruction of the auricle. Most of these represent auricles rebuilt following loss of a lesser or greater part of the helix and the antihelix. If one may judge from the published photographs, however, the reconstructions shown by Pierce and Gillies are rather superior.

Thus, at the present time before a surgeon attempts to reconstruct an auricle he should ask himself 2 questions: First, can I build an ear which from the cosmetic standpoint is presentable and therefore of some satisfaction to the patient? Second, can I do it in a sufficiently limited number of operative procedures to make the procedure a practical one to which the patient is wise to submit himself?

MATERIAL REQUIRED

The normal ear has for structural support two irregular semilunar shaped fibrocartilaginous

Fig. 1. Through either an oblique or a vertical incision the cartilages of the eighth or ninth ribs on the right side are exposed. A lead pattern is used as a guide. Sufficient cartilage is removed as shown in *a*. This cartilaginous block is hollowed out so that the shape of the cavum, the antihelix, and the helix is imitated, *b* and *c*. Allowance is made for the thickness of the flap which will cover the cavum. One is likely not to be sufficiently generous in allowance for the cavum. This drawing shows the incisions in the skin after the removal of the cartilaginous remnants of a malformed auricle. The mastoid region also was hollowed out. A small incision is shown posterior and above the ear through which the cartilaginous framework is inserted in a position judged to correspond in relationship as to height, angle, and anterior posterior direction to the opposite auricle. Along the lateral side of the neck with the base near the tip of the mastoid process, a flap is raised and tubed. This flap is split at its lower end. The smaller flap should be about 12 centimeters long and 1 centimeter wide. Each end is left attached and in the middle a narrow attachment to the larger flap of about ½ centimeter is left uncut for a time.

wings—the helix and the antihelix—which are after all not separated. The cartilages are thin and of rather intricate shape. In no place in the body is there cartilage that may be fashioned exactly into a replica of this natural support. The cartilage in the normal ear is covered by an anterior and a posterior layer of thin skin with little subcutaneous tissue. No exactly similar skin exists on the body which might be used for purposes of substitution. In reconstruction, therefore, one can only simulate the opposite ear.

Autogenous costal cartilage is a rigid material which can be transplanted as Mangold first demonstrated in 1897 and it can be shaped roughly into a form for support. At the present time all the available evidence indicates that autogenous costal cartilage tends to maintain its original cellular structure *in situ* after transplantation for a considerable length of time at least. It is now 10 years since the completion of the first auricle presented herein (Fig. 4). Although there has been some slight shrinkage the auricle is still nearly as large as when first reconstructed. The experimental evidence at least would indicate that autogenous live cartilage shows less of a tendency to be replaced by fibrous tissue than preserved autogenous cartilage (Neuhof). Although in the human, this observation has not been verified, the experimental evidence is considerable that homogenous cartilage tends to cause foreign body and replacement reactions to an even greater extent than autogenous cartilage (Loeb, Neuhof).

Gillies, however, in a recent article (1937) reports several patients in whom he has used cartilage from the maternal ear to reconstruct the pinna and Pierce and Kirkham now are using preserved homogenous cartilage in certain of their reconstructive operations. Undoubtedly, within a few years, we will have definite knowledge as to the permanency of dead preserved and homogenous cartilage in the human.

As the soft tissues in the immediate neighborhood of a destroyed or rudimentary ear are too scanty to afford much bulk and too flaccid to give much stability for the formation of the new auricle, an additional supply is necessary if the new ear is not to appear too small. Although almost from time immemorial skin flaps were transplanted by the so called Indian, French, or Italian methods, it was not until 1916 when Filatof first and then Gillies (1917) (but independently) used the tubed pedicled flap that a workable means of transplanting soft tissues in quantity became available. For the required soft tissue for reconstruction, the skin of the lower neck has seemed to us in the male at least as the most applicable. This skin imitates fairly well the skin of the ear in color and in general texture if not in thickness. The distance of transference simplifies the operative procedure and it is not difficult to cover the operative area by the pedicle of the flap and a skin graft; furthermore, this area is normally covered by a man's collar. Naturally,

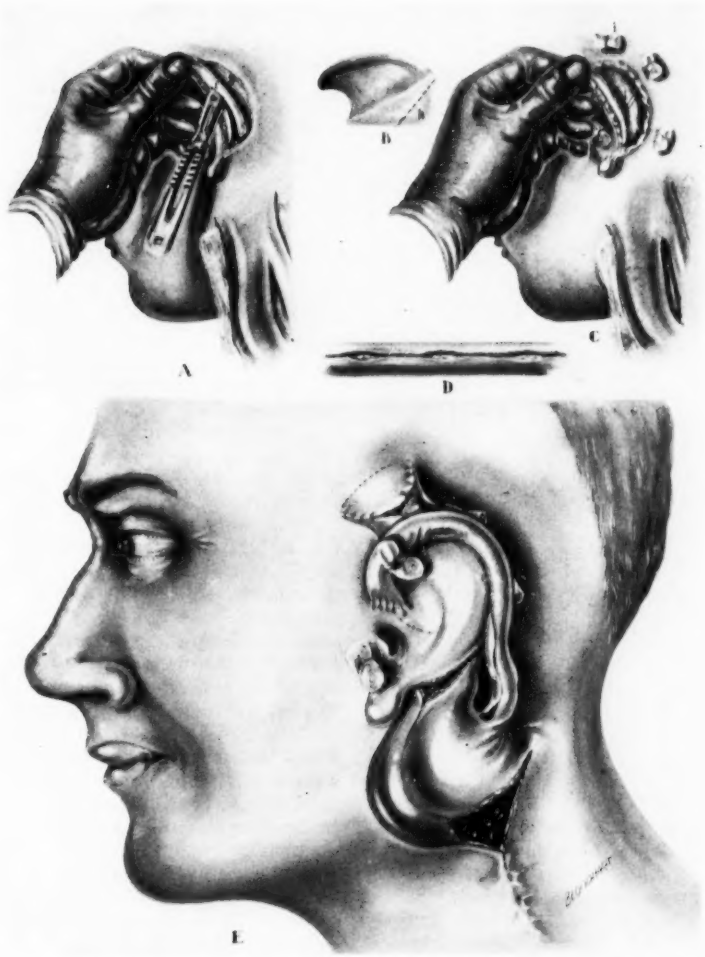

Fig. 2. An incision is outlined posterior to the cartilaginous mass previously buried, A. The anterior skin flap and the cartilaginous mass are turned forward after the cartilage is dissected free from the periosteum of the bone, *g*, on which it previously has been laid. All along the circumference of the posterior edge of the semicircular cartilaginous transplant is trimmed a wedge shaped piece of cartilage with the base of the wedge posterior, *f*, *h*. The tubed flaps previously prepared on the neck are crosscut a second time at their distal ends. The distal end of the large tubed flap is unrolled. This flap is used to cover the posterior part of the new ear or, in other words, the posterior part of the cartilaginous framework, E. The flap is passed an inch or so above the auricle and attached to the scalp side above the ear. This prevents the weight of the pedicle from pulling the ear out of position downward. The small flap is not unrolled. It is used to attach at periodic intervals around the anterior upper and posterior edge of the ear, D and E. A skin graft held in position with a stent of modeling composition is used to cover the periosteum posterior to the new auricle. This is held in place by sutures crossed above the stent at appropriate points. Anteriorly, they are passed through the ear and tied on some type of form such as a small piece of rubber tubing.

Fig. 3. The 2 flaps are crosscut near the new auricle and readjusted and sutured in place. What is left of the pedicle is unrolled, replaced, and sutured to the skin of the neck as the scar is excised, *a*. If the scar on the neck below the pedicled flap is not a pliable one or if there is any contracture, it is excised and the resulting raw area is covered with a skin graft, *b*.

if one should consider it advisable to reconstruct an ear in the female, tissue should be obtained from elsewhere on the body. This would entail a further operative procedure.

INDICATIONS

The indications for the operation are considerably different in the female than in the male. The female can, if she wishes, hide the missing auricle or a deformed one with her hair. Before an attempt is made to reconstruct the auricle, the individual should have attained his full growth, first, because one uses the size of the opposite ear as a pattern and, second, because if the individual has not attained an adult age, the reconstructed ear will not become larger while in all probability the opposite one may grow somewhat.

REQUIREMENTS AND CAUSES OF FAILURE

The requirements necessary for good imitation of the normal ear are correct size, similar outline, nearly equal divergent angle from the head, the same relative height and the same position in an anterior posterior direction and that the new auricle retain its size and shape more or less permanently.

In attempts to reconstruct the auricle satisfactorily, the causes of an unsuccessful outcome, barring infection or failure of the material used for structural support to remain imbedded within the tissues without reaction, have been: (1) the inability to obtain structural support of the proper size and shape, (2) the failure to obtain adequate covering of the proper thickness, texture, and color, (3) difficulty in maintaining the new auricle at an upright level in comparison with the opposite ear, (4) the development of an improper divergent angle of the auricle from the head, and, finally, (5) a tendency for folding, shrinkage, and diminution in size. When one of these stumbling blocks to success was present, the new auricle could not be considered a glaring success but if more than one or all were present, the qualitative result was decreased progressively in accordance with the degree of the enumerated defects.

An adequate plan is a prime prerequisite for success in reconstructing an auricle. In formulating a plan one should err on the side of too much ear rather than too little ear. This caution applies both to cartilaginous and soft tissue requirements. As to the latter, the flaps should be larger than one judges to be necessary. It is easier to discard than to go after more tissues. Not only when building the ear should the plan be slightly more adequate but, as a rule, it is well to plan the immediate final reconstruction to be slightly larger than ultimate requirements demand because during the first year there will be some slight shrinkage of both the soft and the hard tissues of the new auricle. Moreover, the tendency to shrinkage, although slight, is undoubtedly present throughout life. When one takes this advice, however, the fact might be considered that a reconstructed auricle, or any organ which has been reconstructed, if it is too large will attract attention because of its size alone.

Thus, to recapitulate, in the development of a plan for the reconstruction of the auricle, the following desiderata are important: (1) a sufficient amount of soft tissues; (2) a type of soft tissue which can be molded to give certain contours that can not be given by rigid tissues; (3) a sufficient amount of rigid tissues; (4) rigid tissue of a size and shape which simulates most of the larger basic contours of the auricle; (5) a rigid tissue that is more or less permanent; (6) a rigid tissue that is easy to transplant; (7) a rigid tissue that will stand trauma; (8) maintenance of the proper elevation; and (9) preservation of the proper divergent angle from the head.

A B C

Fig. 4. Case 1. A, Photograph of young man 21 years of age with congenital malformation of the auricle. In this patient the cartilage was discarded and the mastoid was hollowed out so as to give a cavity to imitate the cavum. The skin flaps surrounding the cartilage were used to reline the depression left after the removal of the bone from the mastoid. Operative procedures were started April 25, 1928. B, Front view of patient 3 years after the completion of the new auricle, April 1, 1932. C, Lateral view of rebuilt auricle 5 years after its completion, May 4, 1934.

TYPES OF DEFORMITY AND THEIR INFLUENCE ON RECONSTRUCTION

Two types of deformities of the auricle present themselves for reconstruction, the congenital rudimentary or absent auricle and the individual in whom some trauma or disease has destroyed the auricle. Accurate statistics are not available on the prevalency of congenital malformations of the auricle. Over a period of 10 years we have records of 86 cases. Pierce states that congenital malformations of the auricle occur once in 20,000 births. Accidental deformities of the ear are usually: (1) the result of some traumatic accident (the patient shown in Figure 5, Case 2, tore his auricle off sliding down a hill on a sled); (2) those which accompany burns of the face (as a rule, following a burn, the loss is only partial); (3) those which follow operative removal of all or a goodly portion of the auricle most commonly found in elderly persons because of cancer (after this occurrence reconstruction usually is not indicated because of the advanced age of the patient).

In reconstructing the congenitally malformed auricle usually it is inadvisable to open the auditory canal or the aditus ad antrum. (This matter, however, indicates a rather long story and is hardly germane to our subject.) As a rule in our experience, one should remove and discard the rudimentary cartilage and readjust the superimposed skin flaps over the area from which the cartilage was removed. In one case (Fig. 6, Case 3) in which a rudimentary cartilage was larger in amount than usual, I attempted to use it as a basis of structural support for the soft tissues. The result was so unsatisfactory that finally the whole of the rebuilt ear was discarded. The auricle was finally completed after starting from the beginning, so to speak, on the second attempt (Fig. 6, B).

Usually when trauma is the cause of the defect, a part of the auricle is still present. If so, the reconstructive operation should be varied accordingly. The difficulty of the reconstruction will be decreased proportionately to the amount of the ear which remains. On the other hand, a severe trauma may cause not only the destruction of the whole of the pinna but a varying amount of the tissue which surrounds the ear. This may complicate the reconstruction of the auricle, making the procedure more difficult and more prolonged. In the patient shown in Figure 7, Case 4, a large slough due to some "cancer paste" had not only removed the auricle but also the skin about the location of the auricle—especially anterior to the meatus over an area about 3½ inches in diameter. Before one could start to build the new auricle the side of the head had to be covered with a large skin flap.

THE OPERATION

The steps in our operations have been roughly as follows:

A B C

Fig. 5. Case 2. A, Photograph of boy 14 years of age showing lateral view of auricle which had been lost in a coasting accident. Operative procedures were started April 25, 1932. B, Lateral view of patient taken 2 years after the auricle was reconstructed, February 14, 1934. C, Lateral view of patient November 10, 1936. (Note that some of the subcutaneous tissue has disappeared underneath the skin and the cartilage shows a few prominences.)

First operation. As just mentioned, in the total reconstruction of a congenitally deformed auricle, as a rule, the rudimentary cartilaginous masses are removed and discarded. If the auricle is to be rebuilt because of a major congenital malformation, the next step may be the removal of some bone about and posterior to the position of a normal meatus so that a depression in the bone is made which will imitate the cavum or even a rudimentary meatus. The skin flaps which remain after the rudimentary cartilage and bone have been removed are applied directly to the bone to form a lining for the newly formed cavum. In the reconstruction of an auricle which has been lost due to an accident this step ordinarily will not be necessary as the external auditory meatus and the cavum will be present in fairly normal proportions and no removal, deepening, or hollowing of the cortex of the mastoid bone will be necessary.

Fig. 6. Case 3. A, left, Photograph of young man 21 years of age with a congenital malformation of the auricle. Operative procedures were started February 22, 1933. On this boy, because there was a considerable part of the auricle present, I attempted to enlarge it somewhat to make an auricle of good appearance but was unsuccessful. Therefore, I started in all over again and rebuilt the ear according to the method here described. The ear was completed July 21, 1934. B, Photograph taken February 1, 1935, 6 months after its completion. At the present time the auricle needs a little reshaping at the back.

Through either an oblique or a vertical incision the cartilages of the eighth or ninth ribs on the right side are exposed. A lead pattern is used as a guide as to the amount of cartilage which will be needed. Sufficient cartilage must be obtained. A block of cartilage is removed as shown in Fig. 1, *a*. This cartilaginous block is hollowed out so that the shape of the cavum, the antihelix, and the helix is imitated. Allowance is made for the thickness of the flap which will cover the cavum. One is likely not to be sufficiently generous in hollowing out the cartilage beneath the newly formed cavum.

Through a small incision posterior and above the ear after a fairly wide undermining of the soft tissues posterior to the meatus or the position of the meatus in a plane just superficial to the periosteum of the skull, the cartilaginous framework is inserted in a position judged to correspond to relationship as to height and anterior posterior direction to the opposite auricle. The wound is closed by interrupted sutures without drainage

A B C D

Fig. 7. Case 4. A, Photograph of a man 55 years of age who had lost his left auricle due to the application of a cancer paste. He also had a seventh nerve paralysis and the lower eyelid drooped. The problem here was not only to rebuild the ear but also the foundation on which it was to rest. Before we could start to rebuild the ear, it was necessary to lay a large skin flap over the scarred area on the temporal region and the mastoid region. (As he complained considerably of his drooping lower eyelid, a full thickness skin graft was looped beneath the lower tarsal rim and extended high on the inner canthus and the outer canthus, and the outer canthus was narrowed somewhat.) Operative procedures were started October 12, 1935. B, Front view of patient October 31, 1935, after a skin flap was applied and before the lower eyelid was raised. C, Lateral view of patient July 15, 1937, after skin flap was laid on the side of the head and the auricle was rebuilt. D, Front view of patient July 15, 1937. (Note also that the lower eyelid of patient is in a position of correction.)

and a pressure dressing consisting of wet gauze and a marine sponge is placed over it to prevent the formation of a hematoma about the cartilage.

Along the lateral side of the neck with the base near the tip of the mastoid process a flap is raised and tubed. This flap will have to be adequate to cover the posterior part of the ear and to form a small tubed roll which will be used to imitate the helix. The flap is split at its lower end as shown in the diagram (Fig. 1). The smaller flap should be a narrow piece of skin and subcutaneous tissue about 12 centimeters long and 1 centimeter wide. Because of its narrowness it may be that one can not tube it well with stitches. If this be the case it is allowed to tube itself by cicatrization. Each end is left attached and in the middle a narrow attachment to the larger flap of about 1 centimeter is left uncut for a time. The temporary midway attachment helps to guarantee the blood supply. The objective is to form a bifid double tubed flap at the lower end of the flap—one narrow and one fairly large. Before the second operation both of these tubed flaps should be cross sectioned over the clavicular region and resutured back in place.

To summarize, the first operation consists of the preparation of the flap and the transplantation of a cartilaginous framework after certain advisable preliminary preparations have been carried out in the neighborhood of the meatus or in the neighborhood of where the meatus should be. The first operation is performed more appropriately under a general anesthetic although it is not at all impossible to perform it under local anesthesia. After the first operation it is advisable to allow 2 months or more to elapse for recuperation of the tissues which have been disturbed in transplantation or have been transplanted. The dangers of infection are less if an adequate interval of time is allowed after complete healing has occurred.

Second operation. An incision is outlined posterior to the cartilaginous mass previously buried. The anterior skin flap and the cartilaginous mass are turned forward after the cartilage is dissected free from the periosteum of the bone on which it had been laid previously. All along the circumference of the posterior edge of the semicircular cartilaginous transplant is trimmed a wedge shaped piece of cartilage with the base of the wedge posterior.

The tubed flaps previously prepared on the neck are crosscut a second time at their distal ends. The distal end of the large tubed flap is unrolled. This flap is used to cover the posterior part of the new ear or, in other words, the posterior part of the cartilaginous framework. This flap is passed an inch or so above the auricle and attached to the scalp side above the ear. This prevents the weight of the pedicle from pulling

the ear out of position downward. The periosteal raw surface on the cranium is covered with a skin graft.

The small tubed flap is not unrolled. It is used to attach at periodic intervals around the anterior upper and posterior edge of the ear. The fact that it is only attached at intervals of about ¾ centimeter keeps it rolled permanently and thereby the form of the helix is imitated. If the tubed flap is split along its length it will flatten out to a greater extent than is desirable. To imitate the helix closely the tubed flap has to be as narrow as possible.

For pressure and fixation a modeling composition form is molded over a split skin graft. This is held in place by sutures crossed above the stent at appropriate points. Anteriorly, they are passed through the ear and tied on some type of form such as a small piece of rubber tubing.

The second operation can be performed under local anesthesia if desired. Appropriate dressings are applied. They need not be changed for a week. An interval of a month or more is allowed to elapse before the third and final major step.

Third operation. The 2 flaps are crosscut near the new auricle and readjusted and sutured in place.

What is left of the pedicle is unrolled, replaced, and sutured to the skin of the neck as the scar is excised.

If the scar on the neck below the pedicled flap is not a pliable one or if there is any contracture, it is excised and the resulting raw area is covered with a skin graft.

Finally, if there is additional shaping of contour, it is done in the office under no anesthesia if an innervation has not yet developed or under local anesthesia if indicated.

If this operation were to be done on a woman, another preliminary operation would be necessary so that the flap could be taken from some area other than the neck, such as the upper chest or upper back.

CONCLUSIONS

In the 4 individuals herein presented, the defect in 2 instances was of congenital origin (Cases 1 and 3). The oldest of these was built in 1928 (Case 1). At the present time the shrinkage has been only slight. The other congenitally malformed ear was constructed in 1933 (Case 3). Case 2 suffered traumatic destruction of the auricle. It was built in 1932. Case 4 following the application of a "cancer paste" had suffered almost total destruction of the auricle along with the soft structures about the ear. The depth and extent of the slough may be appreciated when it is noted that the patient had a seventh nerve paralysis because of it. The base upon which the new ear was to rest was repaired and the new auricle was rebuilt in 1936.

The operation presented is one developed from an experience which necessarily entailed some trial and error.

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AVOIDANCE OF INJURY TO THE COMMON BILE DUCT

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IT is impossible to explain adequately to a surgeon who has not had the personal experience, the degradation of spirit with its attendant humiliation, chagrin, and remorse that comes with the realization that unwittingly, one has during the performance of a given cholecystectomy, resected, or caused a major injury to, the common or hepatic bile duct.

Some pitfalls and their avoidance in surgical procedures may be successfully learned by precept and textbook example, combined with a modicum of practical experience. Inadvertent injury of the common or hepatic bile duct is a surgical pitfall that may and does trap not only the unwary but also, occasionally, the veteran surgeon. To paraphrase the old adage "the burned child dreads the fire," one who has thus injured these ducts is far less likely to do so again.

Under such circumstances, the true surgical conscience "resteth not" until, by unremitting toil and study, it acquires an abiding knowledge not only of the normal anatomy of the region but, equally important, of the frequent anomalies of the biliary tree and its vascular system, anomalies which the surgeon should expect to be present potentially at any operation in this field. He will also acquire an utter abhorrence of what is so aptly called "grab surgery."

Nowhere, except in certain types of brain surgery, is meticulous, careful, step-by-step, dry, visualized dissection, with insurance of full surgical control, so imperative in avoiding disastrous injury to important structures.

The increasing number of operations performed for persistent biliary fistulas and for obstructive jaundice, due to man-made injuries of the common and hepatic ducts, calls for brief, lucid expositions of the detailed steps which surgeons, of long and occasionally bitter experience in this field, have adopted in their routine work in order to avoid this pitfall.

Several pathways lead to the same disastrous end-result: (1) Hemorrhage from a divided cystic or anomalous artery stump. (2) Anomalies of the arteries (Fig. 1). (3) Anomalies of the ducts (Fig. 2). (4) Unrecognized changes in the normal course of the ducts, that are due to chronic inflammatory scar retractile conditions (Fig. 3).

From the Jackson Clinic.

The major cause of injury to the ducts is hemorrhage from a divided cystic or anomalous artery stump. When the general surgeon first experiences this complication, the field of operation being suddenly obscured by an unexpectedly furious hemorrhage, he is prone to think, considering his estimate of the size of the normal cystic artery, that there must be an injury to the hepatic duct or a large anomalous artery. All efforts to visualize the field or control the hemorrhage through mopping are futile; directly he is applying clamps in every direction at the bottom of the blood pool in an effort to avoid a "death on the table" from hemorrhage. If his efforts are successful, he is usually faced with the predicament of not knowing which one of the several clamps applied is the critical one and decides to leave them all *in situ*, pack with gauze, and get out as quickly as possible. As soon as the artery is divided it retracts, so that its open end lies at or below the level of the common or hepatic duct, and the clamp which secures it is very likely to include in its grasp also the wall of the duct, or one of the other clamps may do so; "bite out" injuries of ducts result.

The surest way to avoid this deplorable injury is routinely to proceed with the operation of cholecystectomy so as to identify the cystic artery, and then so securely ligate it before division of the cystic duct is carried out that this mishap cannot possibly occur (Fig. 4, A).

SOME CAUSES OF EMBARRASSING HEMORRHAGE FROM CYSTIC ARTERY DURING CHOLECYSTECTOMY

1. The unintentional division of the close-lying cystic artery when the cystic duct is divided by scissors.
2. The unlocking of a defective cystic artery clamp.
3. The slipping of a poorly applied ligature during or after operation.
4. A defect in the catgut.
5. The crushing division of an artery by application of a clamp when the tissues are friable.
6. The tearing away of a clamp on the cystic artery stump by the unwitting traction of an assistant.
7. The tearing away of a clamp on an artery stump by movement of the liver when the patient suddenly strains in an effort to vomit.

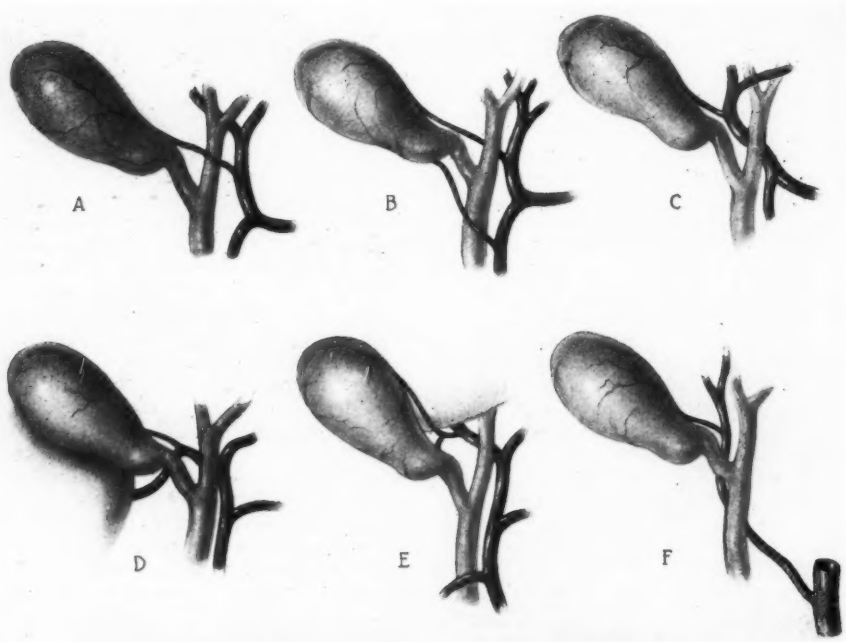

Fig. 1. Some anomalies of the arterial supply of the gall bladder (after Eisendrath, Kyoto, and others). A, The cystic artery arises from the right hepatic artery in the normal manner, but crosses the anterior surface of the hepatic duct. B, Two separate cystic arteries—one arising from the common hepatic artery and passing to the neck of the gall bladder, the second, or accessory cystic artery arising from the gastroduodenal artery and crossing the common duct. C, Either the main hepatic or only the right branch passes behind the hepatic duct, making a wide arch toward the right before giving off the cystic artery. D, Right hepatic artery runs parallel to cystic duct and then arches behind it at the neck of the gall bladder to enter the right lobe of the liver. Before doing so, it gives off the cystic artery at the neck of the gall bladder. E, Most frequent mode of origin of the cystic artery and also of an anomalous branch of the gastroduodenal artery crossing the common duct. The cystic artery usually arises from the right hepatic artery shortly after the latter passes behind the hepatic duct. (Note branch of gastroduodenal artery crossing the common duct near its lower end.) F, Accessory right hepatic artery arising from the superior mesenteric artery (after Kyoto).

8. A linear slit in the hepatic artery by a violent jerk on the cystic artery clamp.

9. The tearing away of a cystic artery clamp by the end of a deep, misplaced abdominal retractor.

10. The tearing through of tissues containing the cystic artery, when the cystic duct is divided because of undue traction with a clamp on a gall bladder which has been mobilized base first.

As examples, the following may be cited:

1. The average non-complicated interval cholecystectomy: the operator, having isolated the cystic duct, divides it at the proper place with scissors; but this time the scissor-tips nip beyond the tissues confined in the jaws of the duct clamps and divide a close-lying cystic artery. To repeat, this pitfall should be avoided by routinely first isolating the cystic duct and then, before dividing it, doubly clamping, dividing, and ligating the tissues containing the cystic artery. This should be made an invariable rule.

2. The clamp controlling the cystic artery may be defective and may unlock just after division of the artery has been accomplished. For this reason it is essential that the clamp to be used be carefully selected and tried out before it is applied.

3. In a field cluttered with many clamps, a well meaning but careless assistant may change the position of a retractor blade so that it exerts direct traction and drag on a deep-lying clamp point and tears it loose (Fig. 4, C). This clamp may be the one on the cystic artery. Therefore,

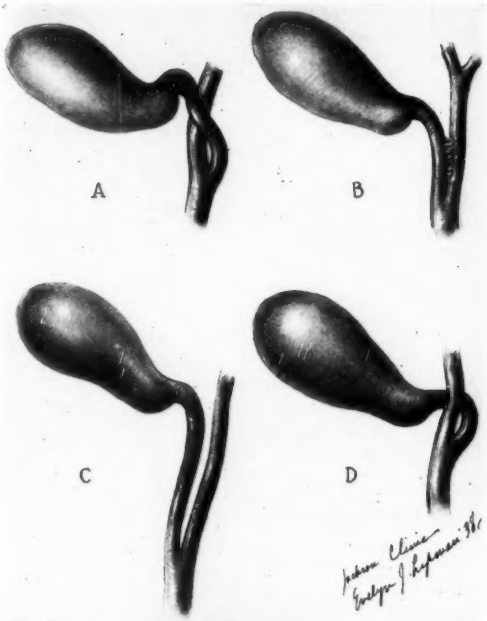

Fig. 2. Anomalies of the bile ducts (after D. N. Eisendrath). A, Anterior spiral type of cystic duct. B, Short parallel type of union of the cystic and hepatic ducts. C, Long parallel type of union of cystic and hepatic ducts. D, Posterior spiral type of cystic duct.

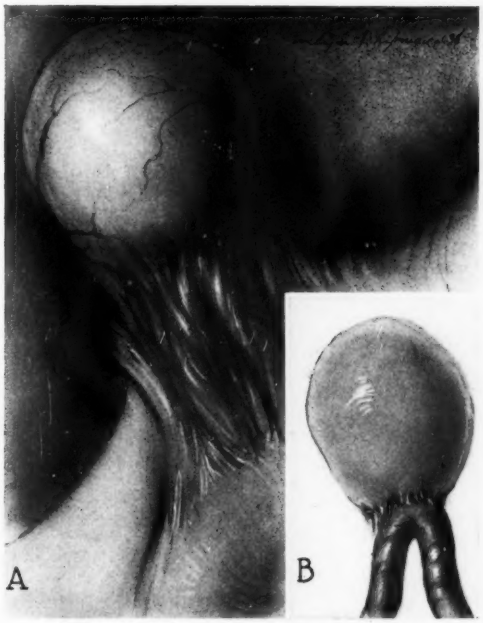

Fig. 3. A, Easily overlooked change in course of hepatic duct due to chronic inflammatory scar retractile conditions. B, Characteristic identifying vessels on common duct wall.

after the cystic artery is divided, it is important that its stump be ligated immediately. As soon as the third knot is placed, the ligature should be severed. We know of an instance in which, due to the slowness of the assistant in applying the scissors, a sudden straining of the patient resulted in such traction on the ligature that was still held by the hand of the operator that it tore loose from the arterial stump.

4. An anomalous position and size of cystic artery may be present, or there may even be an extra cystic artery (Fig. 1, B). Therefore, it is important always to continue carefully to clamp, divide, and ligate all tissues just as one would if he knew this certain condition were present. The surgeon should never proceed with the next step of the operation until the last one has been perfectly completed.

5. If inflammatory changes are present with juicy, friable induration around the terminal cystic duct region, it is essential to be especially careful in the application of clamps, as the jaws may bite through the cystic artery and its adjacent tissues (Fig. 4, B). A No. 2 plain catgut mass ligature placed with a dull-pointed or aneurism needle is sometimes here preferable to the clamp method.

6. If, in this situation, the cystic duct has been divided as the first step, the assistants should be warned against exerting any undue traction on the neck of the gall bladder, as such traction may result in a complete tearing through of the friable tissues containing the cystic artery. The same accident may also be produced by sudden straining of the patient in an effort to vomit while the assistant is holding the clamp in position for placing a ligature.

7. In cases in which inflammatory conditions have advanced beyond the above stage, it may be wise to be content with an "approximate cholecystectomy," assuming there is no common duct complication, and to leave the terminal third or more of the cystic duct, if there are no stones in it, undisturbed at the slight risk of future trouble, rather than to dig blindly into the tissues where anatomical landmarks are obliterated and hemorrhage is difficult to control. This conservative measure especially applies if the patient is

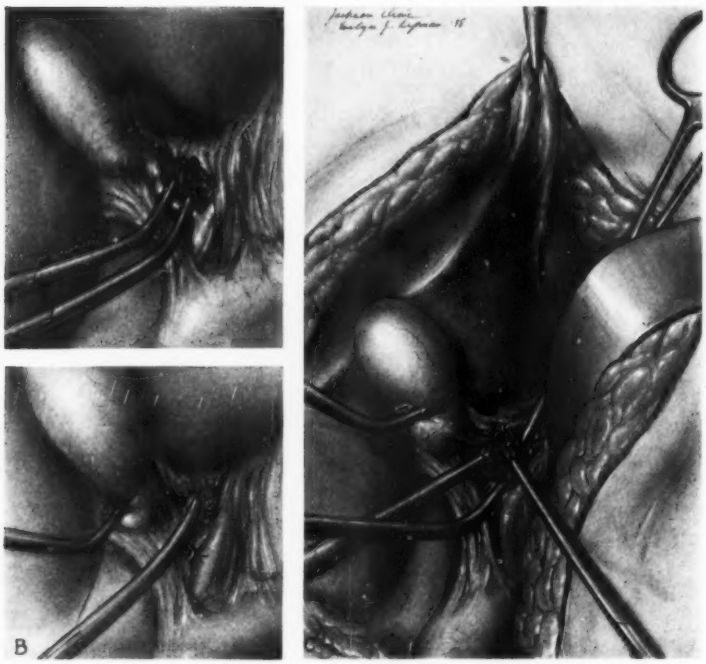

Fig. 4. A, A most important step is routinely to ligate securely and divide the cystic artery before dividing the cystic duct. B, Unwitting misplacement of a deep retractor blade in a cluttered field may result in tearing off cystic artery stump. C, Where tissues are "friably inflamed" an applied artery clamp may bite through the cystic artery.

of the fat-bellied, non-mobilizable liver type, and the surgeon is handicapped by lack of skilled assistants.

CYSTIC ARTERY HEMORRHAGE

The question arises as to what should be done in the presence of a cystic artery hemorrhage. The experienced surgeon with trained assistants is usually able to recatch the cystic artery stump and ligate it w thout causing an injury to the hepatic ducts. Having been requested to write this article for the possible benefit of readers who may be handicapped by lack of proper hospital facilities and trained personnel, I shall describe in a simple fashion the measures that, personally, have been found helpful, in the hope that they may prevent the resort to steps which have, in the past, and certainly will, if used in the future, continue to produce 90 per cent of man-made injuries of the common and hepatic bile ducts. Steps to control bleeding of the cystic artery stump are as follows:

1. If the furious hemorrhage persists and appears uncontrollable, the assistant with the smallest hand should be directed to take his position at the left side of the patient and to pass his open left hand into the wound until his index finger enters the foramen of Winslow and feels the pulsating hepatic artery; then, with his thumb opposing, to shut off this artery, making his forearm and hand as inconspicuous as he possibly can by dragging the abdominal wall to the left (Fig. 5).

2. If the abdominal wall incision is too limited for good exposure, it should be enlarged. This step is imperative.

3. All clamps should be removed.

4. The wound should be mopped out. If a suction apparatus is available, it should be used for both suction and retraction in the depths of the wound.

5. The liver should be mobilized by traction clamps on the divided falciform ligament and on the gall bladder.

6. The light beam should be directed to the best advantage. A Cameron goose-neck, intra-abdominal light may be used to advantage after the blood clots are removed.

7. A long-handled, slender-jawed artery clamp with the jaws slightly open should be placed close to where the retracted cystic artery should be.

8. The assistant should be asked to release pressure on the hepatic artery sufficiently to permit the cystic stump to bleed and then to close the artery clamp on it. If not promptly successful, the clot in the deep recess should be cleaned out and if possible the operator should proceed to inject the hepatoduodenal fold with 2 per cent novocain solution. Continuous closure of the hepatic vessels and portal vein for more than a few moments causes a marked fall (20 to 30 points) in blood pressure and if any prolonged search for the artery stump is probable, it is advisable to prevent this fall by such block anesthesia before proceeding with the search.

9. Figure 6 shows the application of an hepatic tourniquet in place of an assistant's hand. It was devised for intermittent hepatic artery control in excision of hepatic tumors and block dissection of the carcinomatous gall bladder. Experimentally, in dogs, more than 15 minutes of continuous compression of the portal vein may result in irreparable injury to the small intestine. The nut spring was devised to provide delicate, adequate pressure control without producing a crushing effect on the vessel walls. It permits intermittent closure and release of the hepatic artery and portal vein.

Fig. 5. Finger compression control of hepatic artery in case of furious hemorrhage from divided cystic artery.

ANOMALIES OF THE BILE DUCTS AND ARTERIES

While every operator who undertakes the performance of a cholecystectomy owes it to the patient to have at least a cursory knowledge of this subject, some seem never to have heard of it.

Figure 1, A to E, portrays a few of the many situations which might be present in the next patient upon whom the reader operates. In 20 per cent of human beings, the blood supply of the right hepatic lobe comes directly from the superior mesenteric artery and this hepatic branch may meander even so far as to lie across the cystic duct (Fig. 1, F). If mistakenly ligated for the cystic artery, high temperature and death may follow abruptly.

In instances in which the juncture of the cystic and common ducts follows a closed "Y" course (Fig. 7, A), if even slight traction is maintained at the time of application of the duct clamp, the arms of the "Y" consisting of normal flaccid common duct will empty, fold together, and form an apparent prolongation of the cystic duct, and a division here results in a complete resection of the common duct (Fig. 7, B). This fact should always be borne in mind when division of what appears to be an especially long cystic duct is about to be carried out. Careful and minute inspection should reveal the true situation, as the normal common duct is thin-walled, semitransparent, greenish, and presents on its surface characteristic fine vessels. In the shad-belly type of patient, one may occasionally demonstrate to assistants the possibility of this pitfall. Veteran surgeons, when in a suitable confessional mood, are apt to refer to such an experience as most unforgettably harrowing and inexcusable in that the essential technical procedures were not made difficult by an obscuring pathological lesion.

Fig. 6. Author's hepatic tourniquet devised for intermittent control of hepatic vessels in block excision of certain hepatic neoplasms.

If there is any difficulty in ascertaining whether a ductlike structure encountered is a dilated terminal cystic duct or the common duct, it is safer to expose the common duct in its lower non-inflammatory area, open it, and pass a probe upward until the true situation is revealed, rather than to divide the doubtful structure with the hope that it is not the common duct. This situation we have encountered many times when the dilated terminal portion of the cystic duct was fused with the wall of the common duct for several centimeters (Fig. 2, B). When this situation is present, the common duct tractor guide (Fig. 8) serves a twofold purpose: (1) it delineates the common and hepatic ducts; (2) it serves by gentle traction to elevate and bring the duct closer to the operator, thus facilitating dissection.

UNRECOGNIZED CHANGES IN THE COURSE OF DUCTS DUE TO CHRONIC INFLAMMATORY SCAR CONTRACTILE CONDITIONS

As a rule, the patients in this group are usually middle aged or elderly, with a history of chronic biliary distress. The roentgen report shows the presence of a single large, rounded gall stone. At operation, the liver is abnormally mobile, and when drawn up the condition depicted in Figure 3, A, is found.

The gall bladder stands out from the liver like a pear, its base being filled by a large stone. The lower half is completely covered by what appears to be adherent, chronically inflamed, omental tissue. The prospect is for an easy cholecystectomy. The operator begins in what he assumes to be the area of the cystic duct which he exposes, ligates, and divides, and then continues to clamp, divide, and ligate until the gall bladder is removed. Free bile is noted in the depths of the wound. The specimen is examined, and the condition depicted in Figure 3, B, is found to have been present.

I witnessed this procedure many years ago as it was being carried out by an eminent surgeon now deceased, and that experience has always come to mind when I have encountered a case of this kind. This surgeon actually lectured on the dangers of injuring the common duct while he was unwittingly resecting it! In instances like this, it is wise first to incise the gall bladder and remove the stone—there is no bile or free fluid in it—and then minutely to study the interior. If there is no opening for a probe to enter the cystic duct, then, by careful blunt dissection, enough of the wall of the common duct should be exposed to verify its abnormal position and identity by its characteristic appearance (Fig. 3, B).

Fig. 7. A, If a closed "Y" type of junction of cystic and common duct obtains and the tissues are non-inflamed, the slightest maintained traction on the gall bladder may result in the common duct arm folding and assuming the appearance of being a proper continuation of the cystic duct. B, If such erroneously supposed long cystic duct is clamped, divided, and ligatured, complete resection and ligature obstruction of common hepatic duct results. The gall bladder should always be examined on removal.

A possible explanation of this deceiving condition is that, in the early stages years before, a huge hydrops or empyema of the gall bladder, being firmly anchored in its bed, exerted in its subsequent fibrotic changes such contractile power as to draw the hepatoduodenal fold and its contained common duct into its "V" course to the gall-bladder site.

As it is technically far easier to repair an injury to the common duct at the time of its occurrence than subsequently, the operator should always carefully inspect the organ on its removal. If there is any question as to the cystic duct end he should re-examine the depths of the wound, and expose the common duct so as to make sure of its integrity and that it has not inadvertently been divided and closed by a ligature as is illustrated in Figure 7, B, before he carries out the procedure of closure of the abdominal wound.

Fig. 8. Author's common duct tractor guide. Suitable sized tube introduced through small opening in common duct by grasping tube at the end and then regrasping at a suitable position for traction.

SECONDARY HEMORRHAGE

Serious secondary hemorrhage from the sloughing stump of a cystic artery that occurs several days after operation in advanced inflammatory, semi-gangrenous cases in which more or less gauze packing has been left *in situ*, may prove a serious complication and tax the ingenuity and judgment of the surgeon to the utmost. We have known it to occur after the unskillful removal of a gauze pack by an interne. Any such pack should be removed by the surgeon who placed it at the operation.

When packing is indicated, we have adopted the 1 inch gauze strip, placed in accordion fashion with a rubber sleeve between it and the viscera, as it permits of comparatively painless, gradual removal, the trick being to grasp the end of the strip with a straight artery clamp and rotate it, thus winding the strip into a rope for a short distance each day. A few drops of peroxide of hydrogen left on the next layer serves to loosen it appreciably between dressings. Abrupt, rapid removal of gall bladder packs has been known to produce severe and even fatal shock as well as annoying and sometimes serious secondary hemorrhage. By the use of the above method, the entire pack may be removed without exerting any direct pull.

DIRECT POSTOPERATIVE HEMORRHAGE FROM CYSTIC ARTERY STUMP

When, in the hours following a cholecystectomy, the patient presents unmistakable signs of a progressively severe internal hemorrhage—which cannot be accounted for otherwise—the chances are that it is due to release of the cystic artery ligature or to an accessory cystic artery which was not ligated; it may be imperative, after blood transfusion, to re-open the wound, search for and control the bleeding stump—a most miserable experience for the surgeon and one in which he may injure the common or hepatic ducts. To avoid this pitfall, the surgeon should be absolutely sure that in every cholecystectomy the cystic and other anomalous cystic arteries are securely ligated.

SIALOGRAPHY, ITS TECHNIQUE AND APPLICATION IN THE ROENTGEN STUDY OF NEOPLASMS OF THE PAROTID GLAND

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THE term sialography may be defined as the roentgen visualization of the parotid or submaxillary glands after the injection of a radiopaque substance into their respective ducts. The entire duct system, and also the gland parenchyma, can be studied, therefore, by this method in a way comparable to lipiodol studies of other inaccessible organs. In recent years this procedure has been used routinely at the Memorial Hospital and has proved itself a valuable diagnostic adjunct.

This report is concerned with the results of a sialographic study of 23 normal parotid glands and 76 cases of neoplastic disease of the parotid, and includes a description of a method of injection, the behavior of the lipiodol in normal ducts and glands, the roentgen findings in the normal gland, in a group of mixed tumors, and in carcinoma of the parotid gland. In all cases in the neoplastic group the clinical, roentgenographic, operative, and histological findings have been correlated.

The clinical material upon which this study is based consists of over 200 lipiodol injections of the parotid duct system in 125 individual cases. The various diseases studied by this method are listed in Table I.

HISTORICAL

The first roentgen demonstration of the parotid duct system was made by Charpy, who published a "radiogram" of an isolated parotid gland injected with mercury in Poirier and Charpy's *Traite d'anatomie* (21) in 1904. The first practical application of this procedure in a living individual according to Berraud was made by Arcelin. Berraud states that Arcelin in 1913 published the report of a case of a calculus in Wharton's canal which was injected with a bismuth solution prior to radiography. For about 13 years following this report we have been unable to find any mention of this procedure in the literature.

From the Head and Neck Department, Service of Dr. Hayes E. Martin, Memorial Hospital.

Presented in part at the Fifth International Congress of Radiology, September 13–17, 1937.

In April, 1925, Carlsten injected a parotid gland with lipiodol and reported the procedure in 1926. Barsony reported a case in December, 1925, into which he injected 20 per cent potassium iodide to demonstrate a marked degree of dilation of Steno's duct. Barsony found no reference in the literature to a similar demonstration while Carlsten stated in his article that Barsony was reporting a similar case. Uslenghi, in Buenos Aires, described the procedure in July, 1925, and believed it to be original with him. Jacobovici, Poplitza, and Albu (13) in 1926 described the use of sialography in 3 cases, demonstrating respectively a salivary calculus, a tumor of the parotid proved at operation, and a tumor of the submaxillary gland. Keith in 1928 reported the use of the procedure in 1 case of parotitis. In 1930, Rocchi published an excellent article in which he reported the results of a study to determine the best radiopaque medium for the injection and the amount giving the best roentgen visualization. Likewise he reported the clinical use of this procedure in a wide variety of cases, including 3 unproved mixed parotid tumors. Since his report there have been numerous contributions correlating the roentgen and clinical findings in various conditions affecting the salivary glands. A comprehensive review on the clinical uses of sialography was published by Feuz (9) in 1935 and 1936.

TABLE I.—DISEASES OF THE PAROTID GLAND STUDIED BY SIALOGRAPHY

		No. of cases
Normal parotids		23
Non-neoplastic diseases*		26
Neoplastic diseases:		
Benign neoplasms (cysts, lipomas, also including tuberculous adenitis in this group)	7	
Adenocystoma lymphomatosum of Warthin	1	
Mixed tumors	40	
Primary carcinoma of parotid	21	
Metastatic carcinoma to parotid region	2	
Lymphoma	1	
Intraoral carcinoma	4	76
Total cases		125

*This group of non-neoplastic disease of the parotid gland is discussed elsewhere (5).

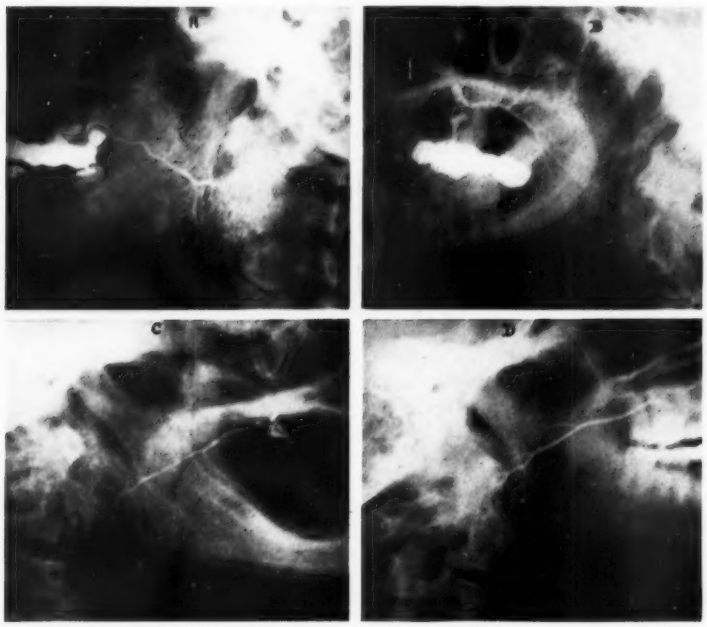

Fig. 1. Lateral projection of 4 normal sialograms, demonstrating variations in size of the duct system as visualized roentgenographically after lipiodol injection. Note the variation in position of the accessory lobule and in A and B the occurrence of several lobules.

ANATOMY OF THE PAROTID GLAND

The *parotid gland*, a racemose gland of the serous type, is the largest of the salivary glands. In anatomical texts its position is described as "below and in front of the ear in the retromandibular fossa, and extending from the zygomatic arch above to the angle of the mandible below." The gland consists of a superficial portion, a deep processus retromandibularis, and one or more accessory lobules.

Roentgen visualization has demonstrated that the gland frequently extends beyond the mastoid tip, below the mandible, and sometimes even to the submaxillary region. Simon has reported a case in which there was a communication between the parotid and the submaxillary gland with congenital absence of Steno's duct.

The processus retromandibularis is best demonstrated on postero-anterior roentgenograms (Fig. 4). It is worthy of mention that in these views, this portion of the gland may extend so far mesially toward the midline, as to be partially superimposed on the lateral margin of the vertebral shadow, and in such cases it may lie in close proximity to the pharyngeal wall and the tonsil. This, as we shall later discuss, is important to remember when dealing with mixed tumors in this region. Seydell has reported a case in which parotid gland tissue was removed from the tonsillar bed at tonsillectomy.

The *accessory gland* is located anterior to the main mass and above the duct. In about 50 per cent of the cases there are 2 or more accessory glands present (Fig. 1, A and B).

The *duct system* consists of numerous branches emptying into a common duct, Stensen's or Steno's, in the anterior part of the gland; the latter runs transversely forward, crosses the masseter, and at the anterior border of this muscle turns inward nearly at a right angle. It then passes obliquely forward between the buccinator muscle and the mucous membrane of the mouth to open in a small papilla on the oral surface of the cheek opposite the second molar tooth.

TECHNIQUE OF INJECTION

We have gained the impression from opinions expressed and queries made by visitors to our

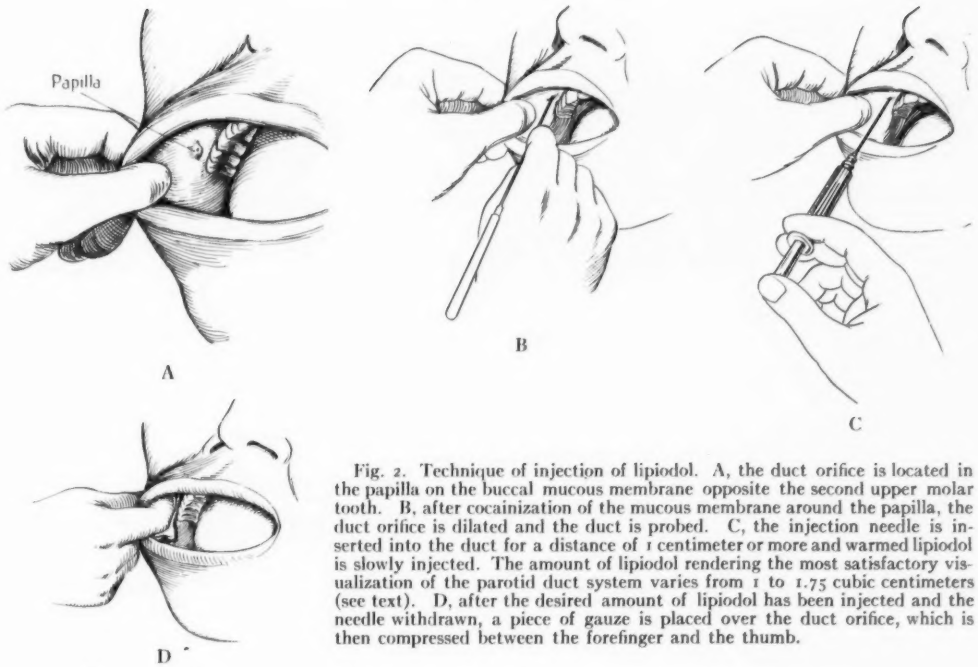

Fig. 2. Technique of injection of lipiodol. A, the duct orifice is located in the papilla on the buccal mucous membrane opposite the second upper molar tooth. B, after cocainization of the mucous membrane around the papilla, the duct orifice is dilated and the duct is probed. C, the injection needle is inserted into the duct for a distance of 1 centimeter or more and warmed lipiodol is slowly injected. The amount of lipiodol rendering the most satisfactory visualization of the parotid duct system varies from 1 to 1.75 cubic centimeters (see text). D, after the desired amount of lipiodol has been injected and the needle withdrawn, a piece of gauze is placed over the duct orifice, which is then compressed between the forefinger and the thumb.

clinic that this procedure has been considered too difficult and too time-consuming to permit its use in everyday practice. On the contrary, we have found the technique to be quite simple and that the entire procedure of injection rarely consumes more than 5 to 8 minutes. A difficulty, only rarely encountered, however, is the identification of the orifice of the duct, after which the subsequent procedures are easily and quickly performed.

The *paraphernalia* needed for the injection of lipiodol are a 2 cubic centimeter tuberculin syringe and a 20 gauge 3 inch needle, the tip of which has been made blunt. Various special cannulas have been devised and used, for which, we believe, there is little indication. A lachrymal dilator or tapered probe and an ordinary blunt tip fine wire probe complete the necessary apparatus. The fluidity of the lipiodol (40 per cent iodine) may be increased by immersing it in hot water immediately before using.

For the injection we prefer to have the patient in a sitting position as it is more convenient to both the patient and the operator. When the duct is easily located and readily probed, the injection can be performed satisfactorily with the patient lying on his back on the x-ray table. As a source of good illumination we use an electrically illuminated head mirror.

The mucous membranes surrounding the orifice are anesthetized by the topical application of a 10 per cent solution of cocaine. We have found surface anesthesia of only slight advantage and have not noted any unusual tendency to drying up the salivary secretions as has been suggested by Payne (18).

The *location of the duct orifice* is in the papilla of the buccal mucous membrane adjacent to the second upper molar tooth (Fig. 2, A). If the orifice is not visible, gentle massage over the gland and duct will express saliva and thereby disclose its location. Drying the papilla with a cotton applicator or by spraying with air will aid in identifying the point from which the drop of saliva was ejected or expressed. When nothing can be expressed from the gland, the flow of saliva may be stimulated by sucking a lemon or some similar substance. Recently we have seen a patient in whom we were able to identify the duct orifice only after 30 minutes of chewing gum and sucking on a piece of lemon. This, of course, represents a rare type of case and not often does this difficulty occur.

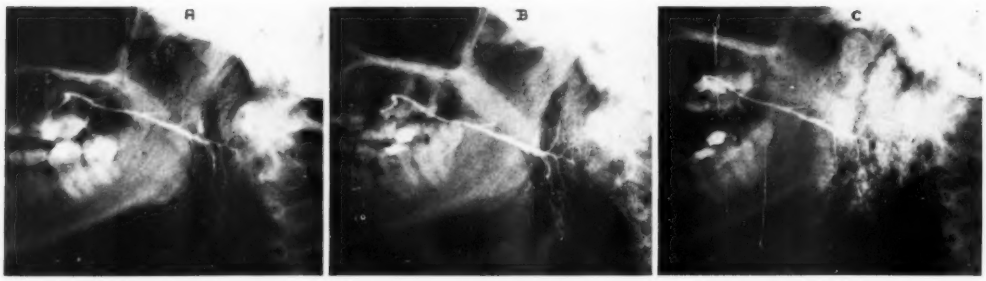

Fig. 3. Study of lipiodol filling in a normal gland. A, one cubic centimeter was injected on February 3, 1937. Entire duct system is well visualized. B, two cubic centimeters were injected 2 days later, February 5, 1937. Note increase in size of main duct. Although in this particular case no diffusion of lipiodol into the gland alveoli is seen, this finding was observed in several of the cases studied. C, three cubic centimeters injected February 8, 1937. The lipiodol has diffused throughout the gland parenchyma. All fine duct detail is obscured.

After the duct is located dilatation may be necessary and can be readily accomplished with a lachrymal dilator or tapered probe (Fig. 2, B). After the dilatation and probing the injection needle is inserted for a distance of 1 centimeter or more. If a thick secretion is obtained it may be necessary to probe the duct. It is frequently difficult to pass the probe for a distance greater than 1 centimeter. In such cases the cheek may be pulled upward and outward to correct kinking or sharp angulation of the duct in the region of the masseter muscle after which the probe can then be passed for a greater distance, sometimes as far as the anterior portion of the gland.

The *injection* should be carried out slowly and gently, since in adequate amounts the procedure is invariably productive of a certain amount of discomfort and pain due to distention of the ducts. In 84 per cent of our cases the onset of this discomfort or pain was noted after 0.25 to 0.50 cubic centimeter of lipiodol had been injected (Table II). It is important, therefore, to proceed slowly in order that the necessary amount (1 to 1.75 cubic centimeters) can be injected with the least amount of discomfort and pain. To prevent the escape of the lipiodol after the needle is withdrawn, the patient is requested to compress the orifice of the duct by squeezing the cheek between the thumb and forefinger with gauze (Fig. 2, D).

TABLE II.—ANALYSIS OF PAIN PRODUCTION IN 38 CASES

Amount of lipiodol causing pain, c.cm.	No. of cases	Per cent	
0.25	10	26.3	
0.33	7	18.4	
0.50	15	39.4	84.1
0.75	2	5.3	
1.00	3	7.9	
1.50	1	2.6	

Injection of lipiodol into the parotid duct system for roentgen visualization is productive of a certain degree of discomfort or pain in each case. Normally, in 84 per cent of cases, this occurs when amounts of ¼ to ½ cubic centimeter are injected. This pain continues until 2 or 2½ cubic centimeters are injected and then all pain disappears—apparently due to diffusion of the lipiodol into gland parenchyma. Usually after ½ cubic centimeter of lipiodol has been injected a palpable enlargement of the gland is noted.

The *roentgenogram* may be made on either an upright or horizontal Potter-Bucky table. Stereoscopic lateral and either single or stereoscopic postero-anterior projections should always be obtained with the head hyperextended to give better visualization of the retromandibular region in the lateral view.

The *after care* of the patient consists of instructing him to massage the parotid region and to chew gum for periods of 1 to 2 hours, 3 to 4 times a day for 2 to 3 days to aid in the emptying of the lipiodol from the gland.

INDICATIONS FOR SIALOGRAPHY

The use of this diagnostic procedure is indicated in all conditions where there is an abnormality or evidence of inflammatory or neoplastic disease in the region of the parotid gland. It is of particular value in the following conditions:

1. To demonstrate the relationship of the normal parotid duct and gland to other adjacent structures.
2. To demonstrate salivary fistulas.
3. To demonstrate the presence of calculi, foreign bodies, or strictures of the parotid duct.
4. To demonstrate and confirm clinical diagnosis of chronic recurrent parotitis.
5. To investigate possible involvement of the gland and ducts in a variety of pathological conditions affecting the cheek and parotid region.

Fig. 4. Same study as in Figure 3. These posteroanterior views demonstrate how far mesially the processus retromandibularis may extend. In this position it lies in close proximity to the lateral pharyngeal wall and tonsil.

6. To determine whether a tumor in the parotid region is an encapsulated growth in the gland substance, a tumor infiltrating the duct system and gland, or a mass extrinsic to the gland and ducts proper.

7. To determine the proximity of the retromandibular process of the gland to a mixed salivary tumor in the tonsillar region.

8. To aid in the planning of an operative procedure in the parotid region.

We believe that sialography is generally contraindicated in acute parotitis since it gives no additional information and may cause the patient more pain by distending the ducts and alveoli of the gland. Csillag and Czunft likewise deem this procedure contraindicated in acute infections. On the other hand, in chronic infections, the lipiodol may have a definite therapeutic effect.

In epidemic parotitis (mumps) we see no necessity for a sialographic study. Hobbs, Sneierson, and Faust performed sialographic studies in this condition and demonstrated typical inflammatory changes. Also in postoperative parotitis there is no indication for the procedure.

We have had no complications in any of our injections. Occasionally the duct orifice may be slightly traumatized by the dilatation or probing. In 1 case of a chronically infected cyst, an acute parotitis, which necessitated incision and drainage, resulted 5 days after the lipiodol injection.

If a sialogram is performed either immediately or several days after a biopsy, a fistulous tract is demonstrated on the sialogram (Figs. 7, D, and 8, C) which obscures detail and may simulate changes on the basis of which an erroneous diagnosis may be made. Therefore, if both procedures are to be performed on the same case, the sialographic study should be completed first.

TABLE III.—AMOUNTS OF LIPIODOL USED BY VARIOUS INVESTIGATORS

	Cubic centimeters
Carlsten (1 case in 1925)	5.0
Jacobovici, Poplitza, Albu (1926)	4.0 (20 per cent iodopine)
Rocchi (1930)	1.5 to 2.0
Barraud (1931)	2.0 to 4.0
Payne (1931)	0.5 to 1.0
Feuz (1932)	2.0 to 4.0
Hobbs, Sneierson, and Faust (1932)	1.0 to 1.5
Jacobovici and Jianu (1933)	4.0 to 6.0
Simon (1934)	2.0 to 5.0
Grasso (1934)	1.5 to 2.0
Hare (1935)	0.5 to 1.0
Kimm, Spies, and Wolfe (1935)	1.0 to 1.5
Blady and Hocker (1937)	1.0 to 1.75

STUDY OF LIPIODOL FILLING AND EMPTYING

In the literature on this subject varying opinions are found regarding the amount of lipiodol necessary for the most satisfactory visualization of the duct system in the average patient. Amounts varying from 0.50 to 6 cubic centimeters have been used (Table III). In our earlier

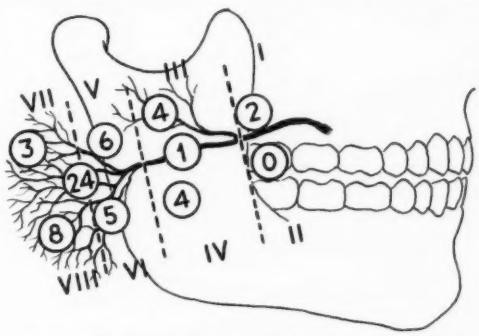

Fig. 5. Diagram, based on a study of 57 cases, showing the frequency and position of mixed tumors in relation to the parotid duct system. The numbers in the circles indicate the frequency of occurrence in the respective positions. The roman numerals represent arbitrary divisions of the duct system.

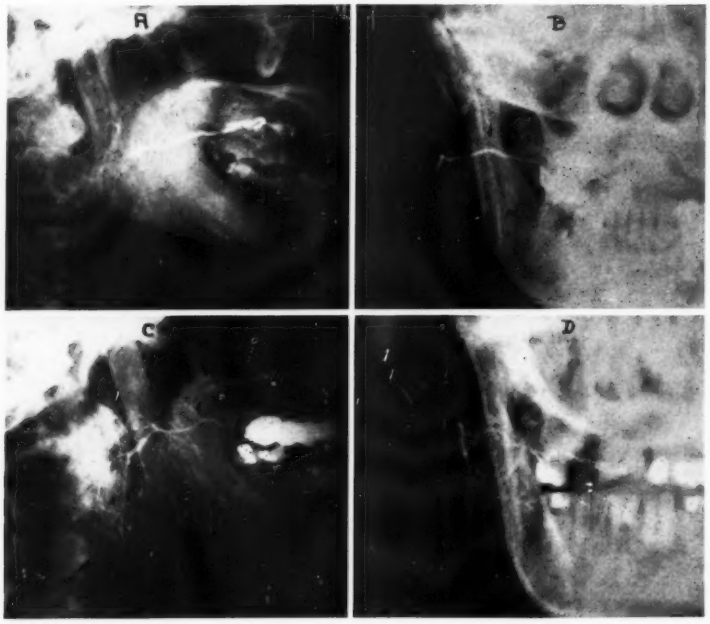

Fig. 6. Mixed salivary tumors of the parotid gland. A and B, these roentgenograms demonstrate the distortion and displacement of the duct system by a tumor located in the tail of the gland and lying under or mesial to the gland itself. C and D, these roentgenograms demonstrate the duct displacement produced by a tumor lying on or lateral to the gland. In comparison to A and B very little distortion of the duct system is observed here. With this preoperative information, the surgeon has a better understanding of the difficulties he may encounter in the case shown in A and B. In C and D, on the other hand, the removal would be a relatively simple procedure.

injections little attention was paid to the amount injected and frequently certain peculiar roentgen appearances of the gland were noted which, at the time, were not clearly understood and frequently were incorrectly interpreted. In order to determine the amount of lipiodol necessary for a satisfactory injection and the reasons for these peculiar roentgen appearances, we made a roentgen study of the normal gland in 10 individuals by injecting different amounts (1, 2, and 3 cubic centimeters) of lipiodol in the same individual at intervals of 2 to 7 days.

Roentgenographic study. One cubic centimeter of lipiodol gives an excellent visualization of the entire duct system and demonstrates the finer ramifications in all portions of the gland. With less than 1 cubic centimeter there is incomplete filling of the duct system. With 2 cubic centimeters of lipiodol, beginning diffusion into the gland is commonly observed and occasionally there is also some enlargement in the size of Steno's duct. The injection of 3 cubic centimeters causes diffusion of the oil throughout the gland substance, obscuring the definition of the secondary ducts and their finer ramifications (Fig. 3). The roentgen picture of this wide diffusion can best be compared with the appearance of a tree in late spring or summer. After the injection of 1 cubic centimeter, on the other hand, the facsimile of the x-ray appearance of the duct system is that of a bare tree in winter. In the German literature the roentgen picture of diffusion of the lipiodol has been termed "Wolkenartiger Schatten" (cloud-like shadow) and "Apfelblueten" (apple blossoms).

The *amount of lipiodol* necessary for a satisfactory injection in the average case, as determined from this study, we believe, is from 1 to 1.75 cubic centimeters. By correlating the amount of lipiodol necessary for a good roentgenographic study and

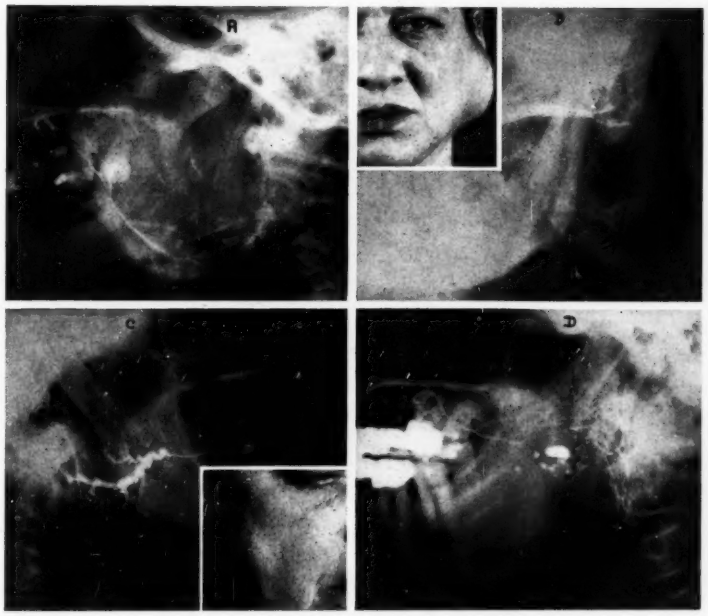

Fig. 7. Mixed salivary tumors of the parotid gland. A and B, the entire duct system is distorted and displaced by the large, somewhat irregular growth. The gland surrounds the periphery of the tumor. Steno's duct is displaced and buckled by the growth. C, small mixed tumor arising in the accessory gland. Both the accessory duct and Steno's duct are displaced caudad and in addition the duct is obstructed, resulting in a distal dilatation of the entire duct system. Note posterior displacement and buckling of the duct. D, large mixed tumor situated in the anterior and caudal portion of the gland, and displacing it backward and upward. The puddling of lipiodol in the tumor is due to a fistulous tract following an incisional biopsy performed several days prior to the lipiodol injection. Such puddling, when superimposed over a duct, may obscure detail or may be confused with localized diffusion of lipiodol as seen in cases of carcinoma. Aspiration biopsy causes similar traumatic changes. In any case, where the two procedures are to be performed, sialography should be completed before doing the biopsy.

the onset of pain (Table II), *we have arrived at an arbitrary rule requiring the total injection of 3 to 5 times as much lipiodol as the initial amount producing discomfort and pain.* This permits individual variation and still provides that a sufficient amount is injected. In some instances we have found it desirable to perform 2 injections of the gland, one for a study of the duct system and the other to visualize the gland substance by over-injection.

Normally the lipiodol empties from the gland in 1 to 3 days, although in cases when 2 to 3 cubic centimeters are injected, or when repeated injections are made, a residue can still be demonstrated from 5 to 15 days later. In cases of obstruction, stricture, or abnormal dilatation, as in infections, lipiodol remains in the gland substance for an even longer period of time.

Recently we have learned that Rocchi in 1930 performed a similar study on a gland removed from a cadaver. He made 4 successive injections of 0.5, 1, 1.5, and 2 cubic centimeters of lipiodol into this isolated gland and obtained roentgenograms following each injection. He concluded that the best roentgen visibility of the gland was obtained when 1.5 to 2 cubic centimeters of lipiodol was injected. Although we were unaware of this study our results are in complete accord with Rocchi's. The reason we give 1.75 cubic centimeters as the maximum amount is that quite frequently we have observed diffusion of the lipiodol into the gland substance when 2 cubic centimeters

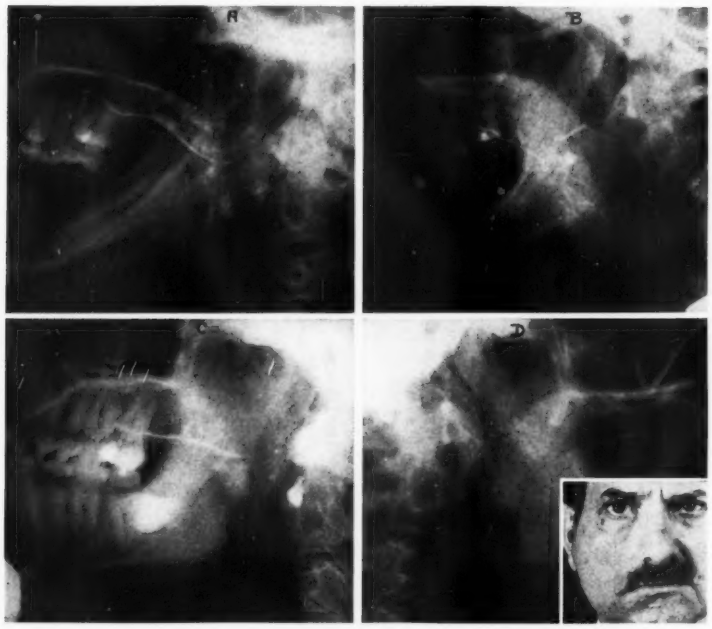

Fig. 8. Carcinoma of the parotid gland. A, M. S., age 139. Epidermoid carcinoma. Note (1) failure to visualize the duct system, only the main duct is seen; (2) abrupt stoppage of lipiodol in the main duct; and (3) filling defects in the gland substance. B, E. H., aged 57. Papillary and solid adenocarcinoma. Note (1) filling defect and displacement of duct system; (2) incomplete filling and failure to visualize the complete duct system in the upper duct branch; and (3) puddling or irregular localized diffusion of lipiodol into the tumor. Preoperative x-ray diagnosis was carcinoma. C, V. E., aged 49. Incisional biopsy reported as intra-epithelial epidermoid carcinoma. Note (1) incomplete duct filling; (2) abrupt stoppage of lipiodol in ducts; and (3) irregular filling defects in gland. Note fistula following biopsy. D, N. S., aged 60. Adenocarcinoma. Findings similar to those seen in A and C.

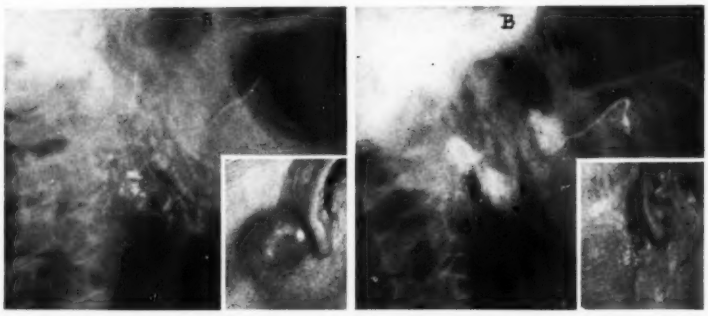

Fig. 9. Carcinoma of the parotid gland. A, T. B., aged 68. Carcinoma. Note (1) poor filling of entire duct system; (2) irregular small defects near periphery of gland; and (3) irregular puddling of lipiodol in the peripheral portion of the gland. B, W. B., aged 73. Adenocarcinoma. Findings similar to those described in A.

was injected. As this is an undesirable effect, because it obscures duct detail, we believe that the maximum amount of lipiodol injected should not exceed 1.50 to 1.75 cubic centimeters.

MIXED TUMORS

This roentgenographic study of mixed tumors is based on an analysis of sialograms in 40 patients with proved mixed tumors in the parotid. In all of these the radiographic findings were correlated with the clinical findings, the pre-operative aspiration biopsy, the operative findings, and by subsequent histological study of the excised tumor.

Location (Fig. 5). These tumors may be found in any region of the cheek, submandibular portion of the neck, retromandibular space, or even in the external auditory canal which lies in close proximity to the gland. The most common locations are the retromandibular and the pre-, sub-, and postauricular areas. The presence of mixed salivary gland tumors in the anterior portion of the cheek near Steno's orifice is uncommon; in our series 2 such cases are recorded. In rare instances a tumor arising in the retromandibular region may extend medially instead of laterally and present intra-orally either in the region of the tonsil or through the buccal mucous membrane between the mandible and the superior maxilla, a possibility which should be remembered when dealing with growths in this region.

A study of the sialograms has revealed the following roentgen findings in mixed tumors of the parotid.

Filling defect. The encapsulated mixed tumor of the parotid gland is usually readily visualized on the sialogram. The most consistent x-ray finding is the filling defect outlined by the displaced ducts surrounding the tumor. The duct system in these cases presents no irregularities or destructive changes. Each duct is visualized in its entirety, although its shape and configuration may vary with the degree of its displacement. If the neoplasm is located near the periphery a small defect may be noted as only the most terminal arborescences become displaced. If the position is central, the resulting defect depends on whether the mass is medial or lateral to the gland. If the tumor lies mesial to the gland, the latter is displaced outward and part of the growth may protrude through its center (Fig. 6, A and B). When the tumor is located lateral or external to the gland only portions of the gland around the periphery of the tumor are displaced (Fig. 6, C and D). In addition to displacement of adjacent gland substance, the duct itself can be displaced in any direction by a tumor located in close proximity. In 1 of our cases the tumor compressed the duct without displacing the gland, and the sialogram demonstrated not only compression of the duct but likewise a resulting distal dilatation due to retention of secretions (Fig. 7, C).

Buckling of the duct is another interesting finding. We have noted its occurrence in the anterior half of the duct as well as in its distal portion. This finding, however, is not diagnostic of mixed tumors as it may occur in any condition in which a mass pushes the duct backward or in which the gland is displaced forward; buckling may be observed, therefore, in inflammatory conditions involving adjacent structures as well as with neoplasms. The buckling is produced by pushing the duct either ventrad or dorsad or by displacing the gland forward, thus crowding the distal half of the duct up on itself toward the gland (Figs. 6, C and D, 7 A, B, and C).

Pressure erosion or atrophy of the mandible, either along the posterior or lateral aspects, has been observed in a number of cases in which large tumors have been present for long periods.

Sialograms simulating those produced by mixed tumors may be seen with benign growths, such as lipomas, branchiogenic cysts, cysts, adenocystoma lymphomatosum of Warthin, tuberculous adenitis, and also with small metastatic nodes.

The occurrence of small mixed tumors in the region of the accessory gland is not uncommon and the changes observed are similar to, although sometimes not quite so marked as, those just described (Fig. 7, C).

The important practical application of sialography in mixed tumors lies not in the demonstration of the presence of such a mass but, as Lange has stated, in the fact that "today the operative plan can be determined before operation more accurately than has been possible up to date." The size of the tumor and its position are clinical observations but the determination of its position in relation to the gland and main duct, and as to whether it lies underneath or over the gland, is reserved to this procedure. Hence, this additional visual information will aid in planning the most suitable approach, thereby avoiding unnecessary difficulty of exposure and possible injury to the nerve, gland, and ducts.

CANCER

Twenty-four of the 76 tumors studied in this series were carcinomas; 21 of these were primary in the parotid gland.

During the analysis of our sialographic studies we were impressed by a rather definite roentgen picture which demonstrated, not only the presence

of a filling defect, but also absence of duct markings, irregularity in the outline of the ducts, and peculiar irregular filling defects in the gland substance itself. On correlating the clinical, roentgenological, and pathological findings in these cases we noted that this roentgen picture was consistent with the histological finding of cancer. In 1931 Pyrah and Allison first noted the fact that " . . . . the gland may be largely destroyed and there may be a considerable filling defect on the sialogram. . . ." Barsky and Silberman in 1932 stated that the absence of duct markings in the region of the tumor indicated a "malignant character of tumor," while Csillag and Czunft in 1934 more accurately described the changes produced by infiltrating tumors. They stated that cancer of the parotid gland "can be recognized by the destruction of the finer ramifications of the excretory ducts and by filling defect due to the destruction of the glandular substance." Kimm, Spies, and Wolfe in 1935 considered "non-filling and irregularity of the ducts" as evidence of carcinomatous invasion. Later in the same year Hare reported similar findings.

In all these reports the roentgen changes are merely mentioned or described in the body of a case report. We believe that their evaluation and importance as a diagnostic criterion of cancer of the parotid gland has not been fully appreciated.

TABLE IV.—CORRELATION OF INFILTRATION AS SHOWN ON SIALOGRAMS WITH HISTOLOGICAL TYPE OF TUMOR*

Type of lesion (Histology)	No. of cases	Sialograms showing infiltration	Per cent
Adenocarcinoma	14	8	
Epidermoid carcinoma	4	4	
Squamous carcinoma	2	1	
Myxochondro carcinoma	1	0	62
Metastatic cancer	2	1	
Lymphoma	1	0	
Total	24	14	58

*In 62 per cent of primary parotid gland carcinomas the roentgen changes caused by infiltration were observed.

The *occurrence* of these very definite roentgen changes in 62 per cent of the carcinomas primary in the parotid is of sufficient import to warrant describing the findings in more detail. We believe that *when this picture of infiltration is observed it is diagnostic of cancer.* The reason for failure to demonstrate these findings in a greater percentage of cases is that the carcinoma arising in a minute focus of the encapsulated mixed tumor is still localized and has not yet infiltrated the gland substance. Even aspiration biopsy in such cases may not be diagnostic, since the aspirating needle may not strike the cancerous area. Only after removal and examination of the entire specimen is the cancer located (Fig. 8).

The *x-ray findings* or changes are to some degree dependent on the location of the lesion and, therefore, fall into 2 general groups.

In the first group, in which the growth is centrally located within the gland substance itself, the following changes are observed: (1) Irregular defects in the gland substance; (2) Distortion of the normal duct alignment; (3) Incomplete filling and irregularity of and failure to visualize the duct system; and (4) Puddling or diffusion of lipiodol in the tumor area, due to destruction of a duct or ducts with escape of the lipiodol into the adjacent tissues (Fig. 9).

In the second group the findings are those observed with growths situated near the periphery or in the tail of the gland. The sialogram in these cases demonstrates the following changes: (1) Complete filling of the portion of the gland and ducts distal to the lesion, unless the latter is located near Steno's duct, in which case the duct system in the gland is not visualized, due to compression of Steno's duct or infiltration and blocking of the duct by tumor; (2) Only slight distortion of normal duct alignment; (3) Irregularity and defects in the portion of the gland involved by the growth; and (4) Irregular puddling of lipiodol in the portion of the gland that is infiltrated.

EVALUATION OF STUDY

Encapsulated growths, such as mixed tumors, as has been shown, distort and produce a displacement of the gland which results in a definitely outlined filling defect, but do not produce irregular defects and deformity of the ducts and gland substance. In the entire neoplastic group we did not find such infiltrative changes in any of the mixed tumor cases not exhibiting carcinomatous changes. In obstructive and in inflammatory conditions puddling and sometimes even slight irregularity of the ducts is seen, but these changes are not associated with filling defects as produced by tumors. The roentgen findings in non-neoplastic conditions are described elsewhere (5).

As is commonly known, metastatic cancer may involve the parotid gland. More frequently, however, it involves adjacent structures and then may extend to the gland. In such cases the invasion of the gland can be demonstrated by a sialogram, and frequently primary and metastatic growths can be thus differentiated.

In one of the cases the clinical findings were typical of a parotid tumor and the aspiration and later incisional biopsy were reported as cancer with "malignant mixed and squamous features."

The roentgenograms of the mandible demonstrated a metastatic defect in the angle of the mandible and the sialogram appeared entirely normal. On this evidence a roentgen diagnosis of metastatic carcinoma was made, which was confirmed 6 months later by a discovery of a primary renal carcinoma.

SUMMARY AND CONCLUSIONS

1. The appearance of the normal parotid gland and its variations as determined by roentgen visualization are described.

2. The technique, indications, and contraindications are discussed. The technique is a comparatively simple procedure for which no special paraphernalia are required.

3. Experimental studies on the normal gland have demonstrated the fact that lipiodol injections of not less than 1 cubic centimeter and not more than 1.75 cubic centimeters render the most satisfactory roentgen visualization of the parotid gland. Because of variability in the size and capacity of the duct system, an arbitary rule has been formulated which permits variation in the amount of lipiodol used and requires that 3 to 5 times as much lipiodol be injected as the initial amount producing discomfort or pain.

4. In the normal, the lipiodol empties from the gland in 1 to 3 days. In abnormal conditions it may remain in the gland for periods longer than 2 weeks.

5. This roentgen study is based on an analysis of various neoplastic conditions in 76 cases, in all of which the clinical, the operative, the histological, and the roentgenographic findings have been correlated.

6. The use of this procedure in mixed tumors of the parotid is discussed. The roentgen findings, depending on the various locations of the tumor, are presented. Sialography has made it possible to determine the operative plan before operation more accurately than has been heretofore possible.

7. The roentgenographic changes caused by infiltration, as observed in 62 per cent of the cases in this series, are described. We believe that when this picture of infiltration is observed it is diagnostic of carcinoma.

8. Illustrations of the various points discussed are presented.

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FAILURES FOLLOWING GASTRO-ENTEROSTOMY FOR GASTRODUODENAL ULCER

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THE status of gastro-enterostomy has remained unsettled ever since partial gastrectomy was first advocated two decades ago as a preferable operation for the treatment of peptic ulcer. In 1925, Lewisohn, in supporting this more radical view, claimed that gastro-enterostomy was complicated by a prohibitive incidence of gastrojejunal ulcer of 34 per cent (18 per cent proved by operation). This contention precipitated a controversy concerning the frequency of that complication which has continued to date. Although this paper constitutes a study of a series of failures of gastro-enterostomy, it is not intended to be a controversial presentation. Its purpose is rather to consider impartially certain observations which we feel may contribute to a better understanding of the modus operandi of gastro-enterostomy and the nature of its complications.

Partial gastrectomy, when applied to cases which have been unsuccessfully treated by a previous gastro-enterostomy, permits a thorough study of the effects of the original operation. The potential ulcer bearing area of the stomach is not only surgically exposed, but the first portion of the duodenum, pylorus, antrum, gastro-enteric stoma, and, as a rule, the associated anastomotic jejunal loops become available as specimens for pathological study (Fig. 1). This communication is based upon a review of 86 such resected specimens as well as upon a consideration of the clinical, pathological, and radiological features of these cases. As 23 of these patients had in addition been subjected to *multiple* previous conservative procedures in attempts to control post-gastro-enterostomy symptoms, an opportunity was also afforded to study the effects of such measures on the complications of gastro-enterostomy. These partial gastrectomies were performed on the gastrointestinal ward service of Mount Sinai Hospital during the period from 1923 to 1936. Cases of gastrojejunal ulcer treated in any other fashion than by gastric resection are not included in this study. The fact that 39 of the gastro-enterostomies were originally done at Mount Sinai Hospital and the 39 remaining at different institutions, would suggest that this material presents a general rather than a particular experience with this operation. It also reflects the difficulty of following and satisfactorily determining the end-results of these patients who are apt to migrate in seeking relief of their persistent symptoms.

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In summarizing our observations on the resected specimens, it seemed best to group them according to the lesion which required re-operation and to discuss them in the light of the previous gastro-enterostomy.

In 58 specimens revealing either an anastomotic or jejunal ulceration, the original duodenal ulcer for which a gastro-enterostomy has been performed was found to be healed in 56, and still active in only 2. In every such instance the stoma was adequate in size, anastomotically well placed, and functionally efficient (Fig. 2).

In 11 specimens, persistent active duodenal ulcerations were present, of which only 2 were associated with active gastrojejunal ulceration (Fig. 3). These latter cases are the ones cited above. All the remaining 9 cases showed inadequacy of the stomas either because of stenosis, inadequate size, or malposition. A consideration of the above findings suggests the following inferences: (1) An *efficient* gastro-enterostomy tends to cause the disappearance of an active duodenal ulcer. (2) Failure of a duodenal ulcer to heal after a gastro-enterostomy is usually associated with a mechanically *inefficient* stoma. (3) While the mechanically efficient stoma tends to heal a duodenal ulcer, it also relatively favors the development of an anastomotic ulcer. (4) The co-existence of an active duodenal ulcer and of an active anastomotic ulcer is rare. We shall again refer to the significance of these findings in considering the mechanics of the healing induced by gastro-enterostomy.

In most instances in which gastro-enterostomy had apparently effected a disappearance of the previously active duodenal ulcer, the resected specimens revealed no other marked changes at the original ulcer site. Scarring at the site of the original ulcer was usually superficial; strictures and obstructing stenoses were not encountered.

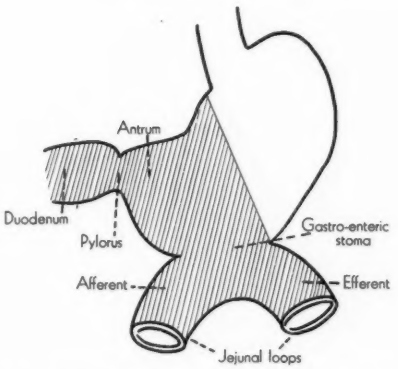


Fig. 1. Anatomical areas represented in resected specimens.

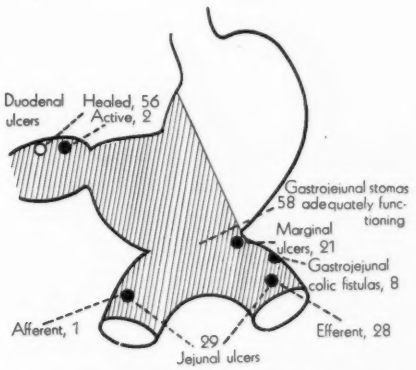


Fig. 2. Analysis of 58 specimens revealing gastrojejunal ulcers.

Often the apparent scarring and deformity observed with the tissues *in situ* were not evident in the resected specimens. The induration and adhesion of the posterior duodenal wall so often noted in primary cases were usually found to be dependent upon *periduodenal* rather than *intraduodenal* changes in these secondary ones. These comparatively minor *objective* evidences of healing cast some light upon the nature of the healing process induced by gastro-enterostomy. It is well known both from clinical and radiological evidence that peptic ulceration tends to undergo a regular cycle of healing and recrudescence. In patients subjected to operation after prolonged medical therapy, it is not unusual to find a disappearance of the ulcer with minimal or no evidence of scarring. In several such patients in whom the primary operation was limited merely to exploration, because of the paucity of findings, subsequent laparotomy because of recurrence of symptoms revealed large active duodenal ulcers. Such healing of an ulcer with the apparent restitution to normal of the duodenum may, therefore, indicate a condition of *latency* rather than that of *cure*. The permanent subsidence of ulcer activity is perhaps only objectively manifested by the scarring and stricture at the ulcer site such as is seen with the so called "spent" or "burnt-out" ulcer which results in a pyloric stenosis. This type of lesion usually does well after gastro-enterostomy and is rarely followed by a gastrojejunal ulcer. However, it is evident from the resected specimens as described above, that this type of healing is not induced by gastro-enterostomy in the ordinary active duodenal ulcer.

The nature of the healing induced in duodenal ulcers by gastro-enterostomy is suggested by a consideration of the following group of 6 cases (Fig. 4). In these patients a gastro-enterostomy had originally been performed for the cure of an active duodenal ulcer. After varying periods of time these patients were subjected to re-operation because of complicating gastrojejunal ulcerations. At that time, it was noted that all evidences of active duodenal ulceration had disappeared; the stomas were therefore disconnected and the normal continuity of the gastro-intestinal tract reestablished. The recurrence of severe ulcer symptoms led to a third operation when it was found that large penetrating duodenal ulcers had reappeared. This series of cases which, in retrospect, has almost the lucidity of a planned experiment, would tend to indicate that the healing of a duodenal ulcer following gastro-enterostomy is not dependent upon any curative effect on its basic cause. It would seem that in these cases gastro-enterostomy induced a condition of latency similar to that encountered in the phase of spontaneous remission which lasted only as long as the gastro-enterostomy continued to function. It would, furthermore, seem that, when the ulcer tendency is still active as manifested by the presence of an active ulcer in the stoma, disconnection may result in the reactivation of what appears to be a healed duodenal ulcer. If the ulcer tendency is still in the active phase, disconnection or new anastomoses may simply lead to changes of localization of the ulcer. This is manifested by 4 other cases. In 1 of these, a fourth operation, a new gastro-enterostomy was added to the 3 outlined above. The duodenal ulcer again disappeared and a new anastomotic ulcer developed. In the 3 other cases, new gastro-enterostomies had been added without disconnecting the old ones which were

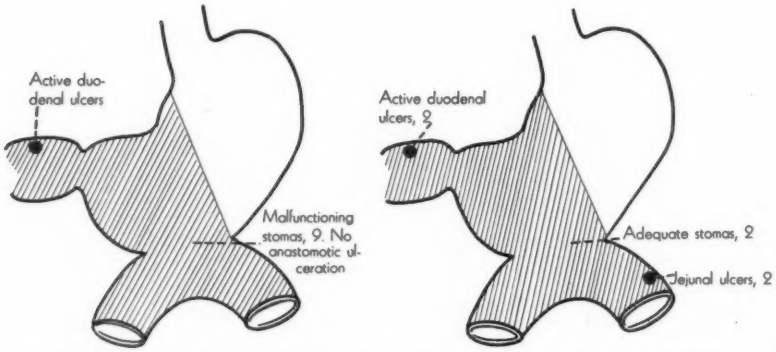


Fig. 3. a, left, Analysis of 11 specimens revealing active duodenal ulcers. b, Analysis of 11 specimens revealing active duodenal ulcers.

functioning poorly and were apparently the seat of ulceration. At subsequent operation, new anastomotic ulcers were found at the site of the 3 new functioning gastro-enterostomies.

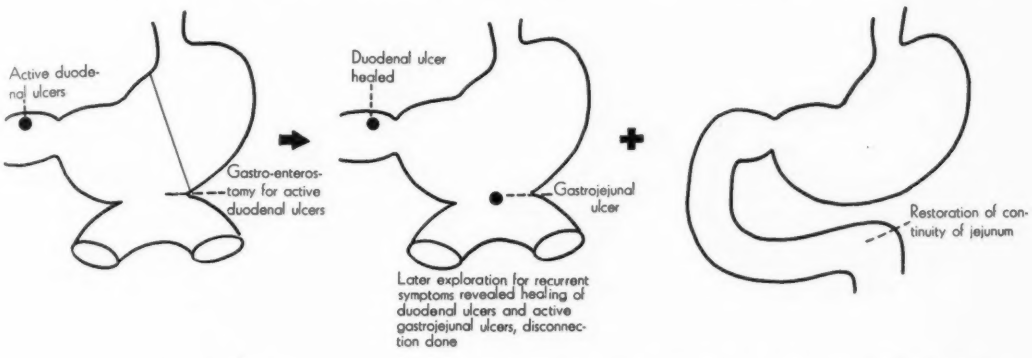
It is instructive to compare the findings in cases in which gastro-enterostomy had failed to relieve the symptoms of lesser curvature gastric ulcers with those observed after its performance for duodenal ulcers. Six patients were re-operated upon because of the persistence of symptoms after gastro-enterostomy for lesser curvature ulcer (Fig. 5). In 5 of these, in the presence of a well placed and well functioning stoma, a persistent gastric ulcer was found. In 1 instance, the gastric ulcer had healed and an anastomotic ulcer was present.

In 6 other cases, gastro-enterostomy had originally been performed for duodenal ulcer. Re-operation for recurrent symptoms revealed that new ulcers of the lesser curvature of the stomach had developed despite the fact that the stomas were well placed and adequately functioning (Fig. 6). In only 1 out of the 12 cases of lesser curvature ulcer associated with adequate functioning gastro-enteric stomas was healing induced by a gastro-enterostomy. These findings contrast strikingly with those observed in the 58 cases cited above of gastrojejunal ulceration, which followed gastro-enterostomy for active duodenal ulcers. It will be recalled that all the stomas were adequately functioning and in 56 the duodenal ulcer was found to be healed. It would, therefore, appear that lesions at the level or proximal to gastro-enterostomies are as a rule not as favorably affected as lesions distal to them. On the other hand, such stomas seem to be much less susceptible to the development of an anastomotic ulceration. This in turn would tend to emphasize the importance of the mechanical factor in gastro-enterostomy as opposed to the chemical, for the chemical effects should be just as great in gastric as in duodenal ulcer. It is difficult to say just how complete and constant the mechanical factor tends to be. It is known from fluoroscopic observations, etc., that gastro-enterostomy does not completely divert the gastric contents through the gastro-enteric stoma. It must be remembered that such observations are usually made sometime after the establishment of the gastro-enterostomy, when there had been an opportunity to relieve the obstructive effects, e.g., spasm—edema resulting from the activity of a duodenal ulcer. It is not unlikely that the mechanical diverting of a gastro-enterostomy varies directly with the degree of such activity.

CLINICAL FEATURES

A review of the specimens revealed the causes for recurrent symptoms after gastro-enterostomy in this series of cases to be jejunal ulceration in 29 patients; marginal ulceration in 21; gastrojejunal colic fistulas in 8; new and recurrent gastric ulceration in 11 and recurrent duodenal ulceration in 17; in 6 of which the gastro-enterostomy had been previously disconnected. Because of the unusual opportunity of studying the anastomotic ulcerations which represent the most serious and important complications after gastro-enterostomy, it is our intention to devote particular attention to clinical, radiological, and pathological features.

Sex. The incidence of recurrent or anastomotic ulcers in women appears to be even smaller than that seen with primary duodenal ulcer. Only 2 of the 78 patients were females. In these 2, the symptoms appeared relatively late in life and in 1 there had been a previous hysterectomy with a cessation of the menstrual function.


Active duodenal ulcers
Gastro-enterostomy for active duodenal ulcers
Duodenal ulcer healed
Gastrojejunal ulcer
Later exploration for recurrent symptoms revealed healing of duodenal ulcers and active gastrojejunal ulcers, disconnection done
Restoration of continuity of jejunum

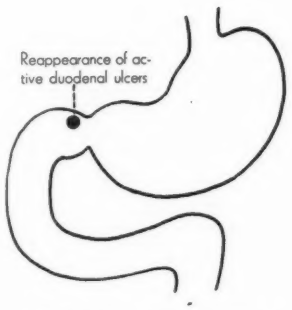


Fig. 4. Six cases of reactivation of apparently healed duodenal ulcer following disconnection of stomas because of jejunal ulceration.

Occupation. These cases represent the clinical material encountered in the wards of Mount Sinai Hospital. The great majority are Jewish, and are classified as factory workers and petty tradesmen with the minority as artisans and clerical workers. There were practically no unskilled laborers or agricultural workers. These patients as a rule are engaged in confining and arduous industries and do not enjoy hygienic and economic advantages. The great majority are heavy smokers.

While the incidence of chronic disease was not noteworthy, 3 patients suffering from thromboangiitis obliterans, that of arrested pulmonary tuberculosis was rather high. There is perhaps no special importance to these features except that they represent the well recognized unfavorable factors of ulcer disease.

Onset and duration of symptoms. In the great majority of cases the original ulcer symptoms commenced in the third or fourth decades and the recurrent complaints appeared in the fourth or fifth. These findings are of questionable significance as they represent the more common periods for the onset of ulcer symptoms.

A study of the symptom free interval after gastro-enterostomy is interesting. In 32, or 43 per cent of the cases, *recurrent symptoms necessitating medical consultation* appeared within the first year; the earliest recurrence was in 6 weeks and the latest after 19 years. The length of this free interval did not seem to bear any relation to the age of onset of symptoms or to the duration of symptoms prior to gastro-enterostomy. Furthermore, it did not seem to be influenced by the addition of any auxiliary procedure, such as exclusion or excision of the primary ulcer. The recurrence of symptoms seemed to take place sooner in those cases of acute perforation supplemented by a gastro-enterostomy than in the general group. In 6 out of 8 such cases symptoms appeared within the first year. Some idea of the chronicity and intractibility of the disease may be derived from the fact that 19 patients had suffered from symptoms for 10 to 15 years, 3 for 15 to 20 years, and 4 for over 20 years.

Symptoms. The symptoms of the patients with recurrent ulceration could not be differentiated from those of primary chronic peptic ulcer. No particular clinical picture seemed to characterize the anastomotic ulcerations except when they were complicated by gastrojejunal colic fistulas. In about half the cases the complaints were of the ulcer type and were quite similar to those experienced prior to gastro-enterostomy. In general the symptoms seemed to be more severe and resistant to therapy. In many cases there were remissions. As they became shorter, the symptoms grew more severe until the continuous suffering forced these patients again to seek surgical relief.

Hemorrhage. There were 13 patients in whom bleeding was a prominent symptom. They may be divided into a group in which hemorrhage was the only symptom, and into another in which the

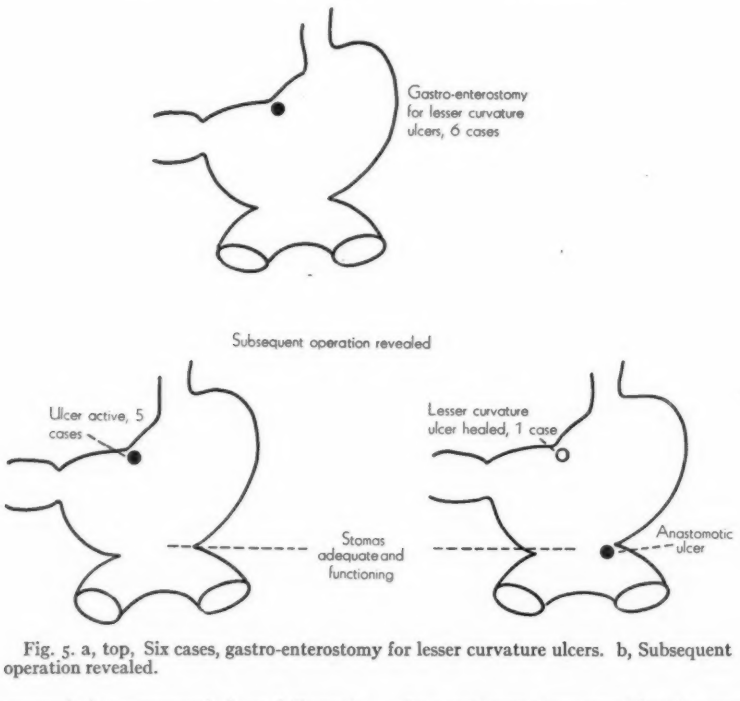


Fig. 5. a, top, Six cases, gastro-enterostomy for lesser curvature ulcers. b, Subsequent operation revealed.

bleeding was preceded, accompanied, or followed by ulcer symptoms.

There were 4 patients with otherwise symptomless bleeding, which was severe enough at times to reduce the hemoglobin to as low as 20 per cent. It is interesting to note that these specimens revealed superficial healing gastrojejunal ulcers. It must be borne in mind, however, that they were subjected to operation only after prolonged bed rest and medical treatment, and it is not unusual to observe similar findings in specimens with primary duodenal ulcers which had been resected after comparable pre-operative treatment. The ulcerations in this type of case are superficial and show no tendency to penetrate into adjacent vessels. It is unlikely, furthermore, that the degree of penetration necessary to impinge upon either a mesenteric vessel or one branch of the middle colic artery could occur without inducing pain.

In view of the fact that conservative measures tend to induce healing of the ulcerations, and that operative intervention in cases of anastomotic ulcer is such a formidable procedure, it becomes a question of serious consideration whether this type of case, with *painless bleeding*, should be treated medically rather than surgically.

In 9 patients there was bleeding associated with pain and in every instance the resected specimens revealed an active penetrating ulceration which showed no tendency toward healing. This type of case apparently presents a different therapeutic problem, and seems more definitely to warrant operative intervention. We have encountered no instance of a fatal hemorrhage from a gastrojejunal or jejunal ulcer in this hospital.

Gastrojejunal colic fistulas. Perforation into the colon with a formation of a gastrojejunal colic fistula occurred in 8 patients and produced varying clinical pictures. In 4 instances the characteristic symptoms of foul eructations, fecal vomiting, and diarrhea developed after a preceding history of pain which ceased in 3 patients with their onset. In 3 patients, diarrhea, and in 1, fecal vomiting, were the first and only signs of trouble. X-ray examination established the evidence of gastrojejunal colic fistula in 1 patient who at no time whatever manifested any clinical symptoms of its presence.

It may be mentioned in passing that every case of recurrent or anastomotic ulceration in this series showed the presence of free hydrochloric acid.

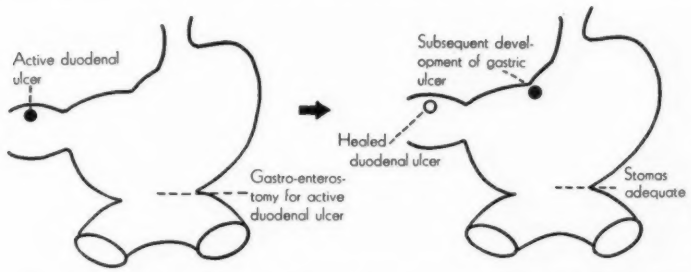


Fig. 6. Six cases, development of gastric lesser curvature ulcers after gastro-enterostomy for duodenal ulcer.

PATHOLOGY

The pathological characteristics of recurrent duodenal ulceration in 17 patients and of recurren gastric ulceration in 11 patients were found to be identical with those of a typical chronic peptic ulcer and require no special consideration.

Pathologically distinct differences were found between the two types of anastomotic ulcerations. There were 29 jejunal ulcers of which 28 were located either in the efferent loop or directly opposite the stoma and only 1 in the afferent loop. These lesions were occasionally multiple, were definitely punched out in appearance, and were either of the same size or smaller than the ordinary duodenal ulcer. These cases of pure jejunal ulceration showed no tendency to involve the margin of the stoma which in every instance appeared to be quite normal. It would appear that operative technique can have little bearing on the development of ulcerations which are either opposite or at some distance from the stoma.

The characteristics of the marginal ulceration at the stoma, of which there were 21, are quite different from those found in the jejunum. They do not have their clear cut definition, are more irregular in shape and distribution, and show a tendency to follow the line of anastomosis and at times to involve a large part of its circumference. This infiltration usually resulted in a rigidity of the stomas, which, however, in most cases remained patulous, but in a few were stenotic. In several patients in whom a Murphy button gastrojejunostomy had been performed, the stoma had shrunk to a size barely admitting the end of a good sized probe and resulted in a mechanically inefficient anastomosis. In these cases the presence of small granulomatous excrescences and areas of polypoid and mucosal hyperplasia suggested that the stenosis might be the result of a previous inflammatory reaction. Incidentally, this was the type of case in which the duodenal ulcer remained active and was responsible for persistent symptoms. While ulceration frequently extended from the stoma into the jejunum, it was never found on the gastric side of the anastomosis.

The tendency to penetration and chronic perforation was rather striking in these marginal and pure jejunal types of ulceration. These occurred in 29 patients and in 8 resulted in colonic fistulas, of which 4 were found to arise from jejunal ulcers and 1 from a marginal ulcer. In 3 patients the site of fistulous origin could not be established. In some cases penetration occurred against adjacent groups of small gut, and in others, especially where the ulcer was located directly opposite the stoma, it extended into the mesentery of the small intestine and resulted in considerable swelling and induration. In the case of one patient a previous operator reported the finding of a large mass of glands and exudate in the mesentery without evidence of ulceration. In most instances chronic perforations tended to become sealed off by the mesocolon or by the still intact wall of the colon, but as previously noted it resulted in colonic fistulas in 8 instances. How frequently perforation occurs into the free peritoneal cavity cannot be determined from this study, for that type of case naturally does not come to partial gastrectomy. However, there were 3 such patients in this series who had had a previous free perforation from an anastomotic ulcer before partial resection was performed. These tendencies to penetration and perforation are important factors in making operative intervention so difficult and hazardous in these secondary cases of anastomotic ulceration.

X-RAY DIAGNOSIS

While it is usually quite difficult and often impossible to differentiate the recurrent and anastomotic ulcerations by their clinical manifestations, x-ray evidence contributes much toward establishing their diagnoses.

Recurrent duodenal ulceration. There were 17 patients who suffered recurrent duodenal ulceration in 11 of whom the gastro-enteric anastomosis was still present, and in 6 it had been disconnected. It will be recalled that in the first group the resected specimens revealed an inadequacy of the gastro-enteric anastomosis. X-ray examinations were available in 8 of these and indicated a deformity of the duodenum in all and stenosis of the stoma in 3 instances, irregular and poor functioning stoma in 2, high narrow stoma in 1, and a failure of visualization of the stoma in 2. A deformity of the duodenum was reported in all 6 patients who had had a disconnection of the stoma.

Recurrent gastric ulceration. X-ray examinations were available in 7 of the 11 patients with recurrent gastric ulceration. In 2 instances the findings were negative, in 1 an hour glass construction of the stomach was reported, and in 4 lesser curvature defects were noted.

Anastomotic ulcerations. For practical purposes the x-ray findings in cases of marginal and jejunal ulcerations may be considered together. The signs establishing such a diagnosis were the presence of a pocket, a tender irregular stoma, gastric residue, and an irregularity or obstruction in the jejunum. There were 9 patients whose hospital record gave no report of a roentgen examination. Of the 41 patients who were subjected to x-ray examination in the hospital, the report was positive in 25, suspicious in 6, and negative in 10. The accuracy of the x-ray investigation is actually greater than these figures would appear to indicate at first glance.

In 6 of the patients on whom the report was negative, such findings are understandable as the radiological examination was undertaken after many weeks of medical treatment for severe hemorrhage. It will be recalled that in these cases the specimens revealed superficial healing ulcerations. There were, however, 3 definite cases of anastomotic ulcer which were reported negative.

There were 8 patients with gastrojejunal colic fistulas; the correct diagnosis was made in each instance. In 5 of these the barium meal showed direct passage of barium into the colon together with some deformity of jejunum or the stoma. In 1, the presence of a fistula was established only after the performance of a contrast enema.

THE EFFECTS OF OTHER CONSERVATIVE OPERATIONS

Twenty-three patients in this series of 86 unsuccessful gastro-enterostomies had been subjected to various types of conservative gastro-enteric procedures in attempts to control their recurrent or persistent symptoms. Twelve patients had had 2 operations, 2 had 3 operations, 4 had 4 operations, 4 had 5 operations, and 1 had 6 operations before a partial gastrectomy was done. It is obvious that these cases merely represent a small series of failures and statistically are of no therapeutic significance. When their results, however, are viewed from the standpoint of the inferences suggested by a study of the resected specimens, an interesting light is shed upon their rationale. They are presented solely for such consideration. It has been indicated that the effects of gastro-enterostomy are due largely to mechanical diversion, and that the well functioning rather than the poorly functioning stomas are likely to ulcerate. Under such circumstances it would appear that in instances of anastomotic ulceration the creation of a new or a more efficient stoma, or the excision of the actual lesion would offer very little expectancy of avoiding a recurrence. Such measures do nothing actually to alter the basic conditions which cause the anastomotic lesion, and apparently permit a repetition of the factors responsible for its original appearance.

Disconnection of the stoma with the addition of a new anastomosis had been done in 8 cases. In 6 the gastro-enterostomy was posterior; the symptoms recurred within 1 year in 3; after 3 years in 1; and after 5 years in 2. In 2 patients in whom a new anterior gastro-enterostomy had been made apparently because of the impossibility of performing another posterior anastomosis, symptoms had recurred in less than a year.

In 3 patients new gastro-enteric anastomoses were made without disturbing the original ones which were found to be contracted. In all 3, ulcerations developed at the new anastomotic sites.

Excision of the anastomotic ulcer with plastic repair had been performed 6 times with symptoms recurring in every case in less than a year.

An operation which recently has found some favor is a disconnection of the stoma with closure of the gastric defect and restoration of the continuity of the gastro-intestinal tract by reconstructing the jejunum. It is argued that if a duodenal ulcer recurs it is more amenable to medical therapy than an anastomotic one; and if gastrectomy should become necessary later, the previous disconnection of the stoma would make it a less formidable operation. It is evident from the experience with the patients in this series that this advantage does not necessarily occur. The procedure of restoring intestinal *status quo* had been performed 6 times in this series with a subsequent recurrence of the duodenal ulcer in every

instance. In 4 cases the symptoms returned almost immediately. The recurrence of ulceration made the dissection of the duodenum much more difficult and hazardous when these patients came to eventual partial gastrectomy, than it would have been at the time of the disconnection of the gastro-enterostomy when the duodenum was comparatively normal.

Although it may seem logical at this time to allude to the results obtained with partial gastrectomy or to the choice of the procedure favored for these cases, we feel the data of this communication do not permit such a presentation. It must be remembered that partial gastrectomy merely served as the medium for our observations concerning gastro-enterostomy and the cases considered were limited only to those in which satisfactory specimens were available for study. They do not include all the gastro-enterostomies which came to radical resection and they constitute a limited percentage of such patients seen in this clinic. When sufficient time has elapsed to allow a comprehensive evaluation of results, we plan to report the experiences of this clinic with partial gastrectomy for the patients previously unsuccessfully treated by gastro-enterostomy.

SUMMARY AND CONCLUSIONS

Partial gastrectomy through the media of its surgical exposure and the tissue resected, permits a direct study of the effects of previous operations upon the ulcer bearing area of the stomach and duodenum. Such a study is the basis for a consideration of the modus operandi of gastro-enterostomy and the nature of its complications. The cases of 86 patients with duodenal and gastric ulcer who had been subjected to partial gastrectomy after a previous unsuccessful gastro-enterostomy are reviewed. Their significant clinical, pathological, and radiological features are indicated. A study of the resected specimens suggests the following conclusions:

1. A mechanically efficient gastro-enteric stoma tends to cause the disappearance of an active duodenal ulcer.

2. Failure of a duodenal ulcer to heal following gastro-enterostomy is often associated with mechanical inefficiency of the stoma.

3. While a mechanically efficient stoma tends to bring about the healing of an active duodenal ulcer it seems also to favor the development of an anastomotic ulcer.

4. Co-existence of active duodenal ulcer and active anastomotic ulceration is uncommon.

5. There are few objective evidences of healing associated with the disappearance of the duodenal ulcer following gastro-enterostomy.

6. Observations are adduced which suggest that the changes induced in active duodenal ulcer by gastro-enterostomy resemble the latency of a remission rather than the permanence of a cure.

7. Disconnection of gastro-enteric stoma because of anastomotic ulceration may result in reactivation of such latent duodenal ulcers.

8. The effectiveness of gastro-enterostomy seems to be due as much to a mechanical factor as to chemical factors.

9. Lesions at the level of or proximal to gastro-enterostomies (lesser curvature ulcers) are as a rule not as favorably effected as lesions distal to them (juxtapyloric ulcers). This would tend to emphasize the importance of the mechanical factor.

10. In cases where gastro-enterostomy has induced remission of duodenal ulcers, ulcers of the lesser curvature have developed at a subsequent date. This would also tend to emphasize the importance of the mechanical factor in gastro-enterostomy.

11. Gastro-enteric stomas performed for lesser curvature ulcer are rarely the sites of anastomotic ulcers.

12. There appears to be a degree of parallelism between the efficacy of gastro-enterostomies in healing peptic ulceration and their own susceptibility to anastomotic ulceration.

13. On the basis of our observations it appears to be illogical to treat anastomotic ulcer either by plastics on the old stomas or by performance of new gastro-enterostomies.

REFRIGERATED CARTILAGE ISOGRAFTS

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San Francisco, California

FOR the past 5 years in the reconstruction of contour defects of the face and its appendages we have used exclusively what we call the "refrigerated cartilage isograft." Cartilage isografts are, for certain types of contour reconstruction, our material of choice as they are easy to obtain; will keep *in vitro* indefinitely; will not absorb; will resist infection; are pliable; and will lend themselves favorably to sculpturing.

The cartilage, mainly rib, is obtained under sterile or unsterile conditions and stripped of its perichondrium. It is thoroughly washed with ordinary tap water to remove any blood which may have collected on the cartilage. This material is then placed in a covered sterile glass container and covered with a solution of 1 part aqueous merthiolate (1:1000) to 4 parts of sterile normal saline. The solution should completely cover all of the cartilage by at least 1 inch. The container is placed in the refrigerator and left there; it is taken out only when the solution has to be changed, cultured, or the refrigerated cartilage used for grafting purposes. When new material is prepared the solution is drained off and changed twice a week for 2 weeks and then only once a week thereafter. New cartilage material should not be added to the now sterile original container unless it has undergone the "Merthiosaline" treatment for at least 1 week and 2 cultures of the second preservative solution have been proved negative. We have made it a routine to obtain a culture from our merthiosaline solution every time a piece of refrigerated cartilage is to be used for reconstruction. We have never had a positive culture return from the preservative solution (merthiosaline) containing the refrigerated cartilage isografts in over 375 cases.

We have used refrigerated cartilage isografts as early as 24 hours after they had been placed in the merthiosaline and grafts that have been preserved for as long as 2 years, but we strongly advise that any cartilage isograft not be used until it has been refrigerated in the merthiosaline for at least 1 week and negative cultures of the solution are obtained by the operator. Refrigerated cartilage isografts that have been preserved over 6 months are just as efficient as a fresh batch of cartilage. This long waiting period although not advisable does not materially affect the cartilage as a graft.

Macroscopically, the fresh cartilage and the older cartilage are identical except that some of the older material is slightly more pliable than when first obtained and, microscopically, occasionally small vacuoles are noticed in the sectioned cartilage that has been preserved over 2 weeks.

Of the 375 transplants done, local infection developed in 6 cases. This occurred mostly in grafts that were used to reconstruct the nasal bridge or tip where external sterilization is difficult. These infections responded to local treatment with all of the grafts remaining *in situ* except any portion of a graft that became exposed. The exposed portion of the graft was gradually digested or was surgically excised to speed up wound closure. This latter treatment was the usual procedure as it materially shortened the postoperative care. If a refrigerated cartilage isograft becomes infected there are several alternatives—the whole cartilage graft may be removed immediately, the infection subsides rapidly, and the wound heals in a short time. If good dependent drainage is established the graft can be left *in situ* and it will survive, but healing will be delayed. On several occasions, to speed recovery where nasal bridge transplants were contaminated, intranasal or columellar drainage points were established and the graft irrigated with merthiosaline introduced through the nasal skin into the graft bed by hypodermic syringes. This should not be done under pressure and should be done only when through-and-through drainage has been established. The solution, merely acting as an irrigator, is injected into the graft cavity and not into the skin or subcutaneous tissue.

Only one total graft was removed and this was taken out because of a streptococcic infection through its point of introduction 48 hours after it had been placed under the skin of the nasal bridge. The symptoms subsided under local treatment as soon as the graft was removed and adequate drainage provided. This infected graft was thoroughly washed in saline solution, refrigerated in merthiosaline, and kept for 6 months. It was then felt that the site to be grafted had recovered from its infection, so the original graft was reintroduced. Healing occurred *per primam* this

time. Infected cartilage that is removed can be resterilized, preserved in merthiosaline, and used again.

After a 5 year waiting period we find that all of the refrigerated cartilage isografts that have been transplanted have retained their original size and identity, except those parts of the 6 grafts that became exposed and 1 small nasal bridge graft that entirely absorbed.

The 1 graft that completely absorbed was 7/8 inch long, 1/4 inch high, and 3/8 inch wide. It was used to build up a luetic nose which was noticeably lacking in skin covering and mucosal lining. The graft was unfavorably situated under tension and an opening occurred between the graft and the nasal cavity. The continual mild infection plus the exposure of the graft gradually caused its disappearance. An additional refrigerated cartilage isograft was used on this patient after a 6 months waiting period and that has remained *in situ* after 3 years.

The refrigerated cartilage isografts are most efficient, highly satisfactory, and economical for the patient needing contour restoration. Their use eliminates the pain and disability that accompanies a rib cartilage resection, which in itself is often more disabling than the correction of the deformity. The use of cartilage isografts always gives one an abundance of easily obtainable material that is simply sterilized and kept on tap in the refrigerator where it is available at all times. The refrigerated cartilage isografts can be interchanged regardless of age, sex, color, race, or blood grouping. Cartilage young in years (under 16 years) due to its pliability is not good contour building material. Refrigerated cartilage isografts stand infection well, will not absorb, and only occasionally cause slightly more of a local reaction than do autogenous grafts. This reaction is not severe and when it subsides the resulting pericartilaginous fibrosis fixes the graft more firmly in its bed so that no movement is elicited on digital palpation. This is a helpful sequela for it fixes the graft in its proper location. The cartilage isografts bend occasionally but with much less frequency than when only autogenous grafts are used. This is probably due to the fact that when the perichondrium is removed and the cartilage placed in merthiosaline it assumes the shapes that the internal strains and stresses of the cartilage cells dictate. Grafts can then be sculptured from this cartilage of the required shape to fit an existing defect. Those few grafts that have bent out of position are the result of (1) the graft being too long for the pocket; (2) the external pressure as measured by the skin elasticity not being evenly distributed over the graft. If the pressure is greatest in the middle of the graft one or both ends will be forced upward. The pressure may be greater at the ends of the graft without materially bowing the center as this is the thickest part of the graft and there is less give to it. On numerous occasions cartilage isografts were accurately sculptured and then placed in the merthiosaline which sterilized and preserved the graft until it was ready for use. If any curling should occur it will take place in the solution and a correction can be made before transplantation is carried out.

Over the years, for confirmation, we have presented to other surgeons our methods, technique, and the results of this work and from personal communications we find they have all been highly pleased with the results they obtained with this type of graft. Dr. Claire Straith reports his results but neglected to mention his source of information obtained from our original work.

CONCLUSIONS

1. Cartilage isografts can be sterilized, preserved, and refrigerated in merthiosaline for an indefinite period of time. The length of time of preservation does not materially affect the cartilage as a graft.

2. Infected refrigerated cartilage isografts can be resterilized and preserved for use at a later time.

3. Merthiolate (1:1000) 1 part and sterile normal saline 4 parts when refrigerated act as an efficient antiseptic and preservative for cartilage isografts.

4. Refrigerated cartilage isografts are efficient and economical for the patient requiring reconstruction surgery. They eliminate the necessity of rib cartilage resection, give one a storehouse of easily available material that can be interchanged regardless of age, sex, color, race, or blood grouping.

3. Refrigerated cartilage isografts at times cause slightly more of a local reaction but this is a helpful sequela. They bend or curl with much less frequency than do autogenous cartilage grafts.

6. Refrigerated cartilage isografts are, for certain types of contour reconstruction, our material of choice as they are easy to obtain; will keep *in vitro* indefinitely; will not absorb; will resist infection; are pliable; are easily sterilized; and will lend themselves favorably to sculpturing.

We express our sincere appreciation to Dr. A. Moody and Dr. S. Leland, of San Francisco, for the co-operation and assistance they have rendered in helping to solve the many problems that confronted us in this work.

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SURGICAL CONSIDERATIONS IN REMOVAL OF STONES FROM THE KIDNEY

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DEFINITE advances, both medical and surgical, have been made in the management of nephrolithiasis during recent years, and consequently late results following the removal of stones from the kidney have been correspondingly improved. Accurate pre-operative roentgenologic localization of calculi has rendered diagnosis almost infallible, and as a result the surgeon usually knows the number, size, and location of stones that must be removed before the incision is made. Improvements in anesthesia and in surgical technique have not only reduced the risk of operation but have enhanced the likelihood of an ultimate satisfactory result. The importance of proper post-operative treatment has become widely appreciated. The present discussion, however, will be limited largely to mention of certain surgical considerations that seem significant in the removal of stones from the kidney.

EXPOSURE OF KIDNEY

As in other types of surgery, probably no single factor is of more importance in the surgical treatment of nephrolithiasis than adequate exposure. The type of incision which affords the best view of the renal fossa and permits mobilization of the kidney most readily, begins high in the costovertebral angle and follows the course of the last rib anteriorly approximately 1 centimeter below the lower border of the rib. Continuation forward to the downward prolongation of the anterior axillary line is usually sufficient. The incision may be carried as far forward as necessary, however, and its length is commonly determined by the size of the patient and by the relative position of the kidney. All muscles encountered along this incision, down to and including the dorsolumbar fascia, may be severed without fear of subsequent herniation if proper closure of the wound is accomplished. Various muscle-splitting incisions have been described, but these are more time consuming, are unnecessary for a strong wound, and may limit exposure. Care should be taken to avoid the ileo-inguinal and ileohypogastric nerves which course just beneath the dorsolumbar fascia downward from the costovertebral angle immediately lateral to the erector spinæ group of muscles. If the kidney is placed unusually high or is particularly adherent in the region of the upper pole, or if it is fixed in a high position as the result of a previous operation, difficulty may be experienced in mobilizing it. In order to facilitate exposure under these circumstances, the twelfth rib may be fractured by a direct upward pull and left *in situ*. If adequate exposure is not obtained in this manner, subperiosteal resection of the twelfth rib increases the height and the breadth of the incision and enhances the exposure of the upper pole of the kidney.

After the desired incision is made, the kidney may be readily exposed by opening the fascia of Gerota near the costovertebral angle and retracting this opening toward the midline. If there is much perirenal inflammatory reaction, the peritoneum may be adherent to the anterior surface of the kidney and it should be carefully reflected in order to avoid entering the abdomen. If the

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peritoneum is accidentally or purposely opened it should be closed before the pelvis of the kidney is opened.

EXPOSURE OF RENAL PELVIS

In order to obtain the best view of the renal pelvis it is advisable to mobilize the kidney freely so that it may be raised well out of the depths of the wound. As an assistant holds the kidney directly upward from the wound, with one hand placed over each pole, which is covered with gauze, the renal pelvis may be identified posteriorly at the hilus of the kidney. Usually the peripelvic fatty tissue can be removed from the posterior aspect of the pelvis without difficulty. Occasionally, if there is much inflammatory reaction present, the peripelvic fat may be edematous, indurated, and adherent, and it cannot be readily separated from the pelvis. Usually, however, this tissue can be removed over a sufficient area to give an adequate view of the pelvis. Palpation of a calculus within the pelvis serves to identify the position of this structure with certainty. If one is uncertain about identification of the pelvis, however, a small aspirating needle may be inserted into the region in question in order to be certain before an incision is made. Should the needle inadvertently enter the renal vein, a moment's pressure with the finger is adequate to control bleeding. In a limited number of cases one finds the pelvis situated anteriorly, and, if after searching on the posterior aspect of the renal hilus the pelvis is not encountered, such an abnormal position should be suspected and a search made anteriorly. Should the pelvis not be readily located in this region, it can always be located by identifying the ureter and tracing it upward.

It is usually advisable to immobilize the wall of the pelvis in some manner before it is incised. Allis forceps may be employed for this purpose, or a single retraction suture may be placed on each side of the line of anticipated incision into the pelvis. As traction is made on the forceps or sutures, the anterior wall of the pelvis is immobilized and separated from the opposite wall, thereby eliminating any danger of incising both anterior and posterior walls at the same time. If the extrarenal pelvis is small, exposure of the pelvis may be greatly increased by placing two small, smooth, right-angled retractors against the renal parenchyma which overlies the pelvis and retracting toward the convex border of the kidney. The additional amount of pelvis that may be exposed by this method is oftentimes very surprising.

INTRARENAL EXPLORATION

After the pelvis is opened by an incision which is usually placed in the direction of its long axis, stones within the kidney can ordinarily be removed with little difficulty. Pre-operative knowledge of the exact location of a given stone within the kidney facilitates its discovery at the time of operation.

Various types of forceps bent in the distal portion at a wide variety of angles have been designed and may be used in performing pelviolithotomy. The ordinary Mixter forceps is quite satisfactory in a high percentage of cases. In exploring the interior of the kidney with forceps one should always exercise great care not to tear the mucosal lining of the pelvis or calyces. Such trauma leads to bleeding, to injury to the parenchyma, and adds to the difficulty of locating and removing calculi. If a stone remains that cannot be located with the forceps, exploration of the interior of the kidney with the tip of the finger, if the pelvis is of sufficient size, is one of the most satisfactory methods of determining for certain whether any calculi remain. Instruments for visualization of the interior of the kidney have been described, but these are not always satisfactory and as a rule are not necessary.

COMPLETE REMOVAL OF ALL STONES

The importance of completely removing all calculi and stony fragments cannot be overemphasized. Undoubtedly many so called cases of recurrence are not in fact true recurrences but merely represent the persistence and perhaps growth of calculi or portions of calculi which were present but not removed at the first operation.

In addition to accurate pre-operative knowledge of the number, size, and location of the calculi, and careful intrarenal exploration with forceps and perhaps with the finger, there are other aids to complete removal of all stones. Small stones and sandy material may oftentimes be evacuated by lavage of the pelvis and calyces with sterile water or saline solution. This may be accomplished by inserting the nozzle of a syringe directly into the pelvis or by using a soft rubber catheter that is placed at any desired point within the kidney.

The use of roentgen rays at the time of operation obviously is most desirable. Fluoroscopic examination by a trained roentgenologist in a darkened operating room is usually of great value to the surgeon who is searching for an unlocated calculus. In addition to the fluoroscopic examination, a roentgenographic plate taken at the time of operation and developed immediately by

portable equipment located nearby affords definite information as to whether or not all stones have been removed. Nephrolithotomy may be necessary at times to remove one or two stones which remain. When one is satisfied there are no remaining calculi, the pelvis may be closed by several interrupted stitches of catgut. The line of closure of the pelvis may be covered, if one desires, by the nearby peripelvic tissue.

NEPHROLITHOTOMY

When a large branched stone is present, or when a calculus is located in the calyx the isthmus of which is too small to permit removal of the stone through the pelvis without undue trauma, nephrolithotomy may be advisable. When marked caliectasis is present and the cortex is accordingly very thin, an incision through the cortex in order to remove a calculus causes very little damage to the kidney and may obviate the necessity of a technically difficult pelviolithotomy. At times the location of the most desirable area on the cortex from which to extract a calculus situated in a calyx may be advantageously determined by pressing the finger which has been inserted through the pelvis against the calculus, thereby forcing it against the cortex and making it more easily located on the parenchymal surface of the kidney. The palpation of a soft area on the cortex also serves to identify a dilated calyx which contains a calculus.

An extensive incision in the cortical surface of the kidney from one pole to the other along the convex margin is seldom required. When extricating a large branched calculus that fills the pelvis and all calyces, such a procedure may be necessary. When the kidney is incised so generously, loss of blood can be greatly reduced and exposure enhanced by temporary compression of the renal pedicle with a large rubber covered clamp. Following removal of the stone, large individual bleeding points should be ligated by mattress sutures before the cut surfaces of the kidney are approximated by a similar type of suture. This is accomplished by mattress sutures tied over small pieces of muscle. The renal capsule may then be reunited by a continuous suture.

NEPHROSTOMY

If the kidney is extensively damaged as the result of longstanding partial obstruction, if considerable infection is present, if infection with Bacillus proteus exists, if there is any doubt concerning adequate drainage from the kidney, or if there is much bleeding into the pelvis or calyces after stones have been removed, it is usually advisable to perform nephrostomy. The advantages of nephrostomy under such circumstances have been frequently discussed. It is desirable to have the nephrostomy tube leave the renal pelvis through the lower calyx and traverse the various layers of the wound in as straight a line as possible. This is especially important if one anticipates the necessity of keeping the tube in place for a considerable period of time. When the tube is so placed, a straight tract results and changing of the tube is thereby facilitated. If nephrolithotomy has been performed, the nephrostomy tube may leave the kidney through the nephrotomy incision in order to avoid additional damage to the renal parenchyma. Multiple nephrostomy tubes may be inserted if desired, though this is seldom necessary. It is always important to make certain that the nephrostomy tube is placed dependently in the renal pelvis or has an opening in the portion of it that is in the dependent part of the pelvis. In addition to providing excellent renal drainage during the early postoperative period, drainage by nephrostomy may be maintained permanently should this be necessary. A nephrostomy tube may also be utilized for lavage of the renal pelvis and aspiration of inspissated material which might form the nidus of a subsequent calculus.

PREVENTION OF RECURRENCE

In the past, the incidence of recurrence of renal calculi has been variously estimated at from 10 to 40 per cent. At present I believe that the frequency of recurrence is definitely less in properly treated cases. Nevertheless stones reform in the kidney sufficiently often following complete surgical removal to merit careful consideration of this possibility in the treatment of each patient. Adequate treatment includes adherence to certain general medical and surgical principles.

Medical aspects. From the medical point of view the importance of infection in the urinary tract has received well considered emphasis. Every patient who has a calculus in the kidney should have careful bacteriologic studies made of the urine both before and following removal of the stone. At the same time the hydrogen ion concentration of the urine should be determined. Adequate treatment necessitates complete eradication of all bacteria from the urinary tract before the patient is dismissed. Preferably, three consecutive negative cultures should be obtained. Treatment will vary depending upon the type of organism present. The management of infection in the urinary tract will not be discussed in detail, but in general, proper acidification and the use of

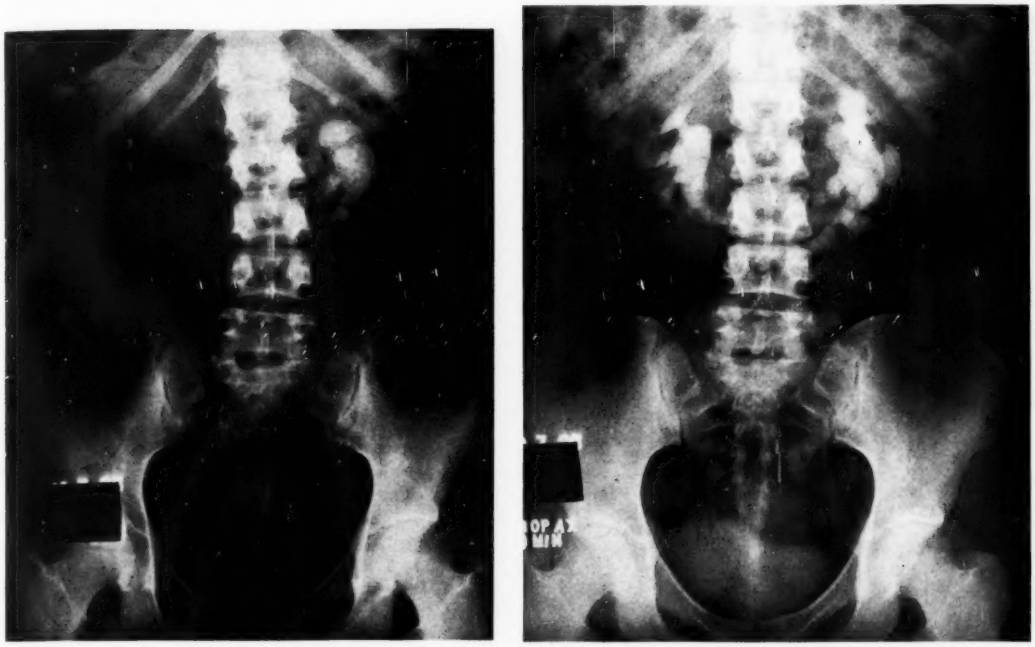

Fig. 1. a, left, Original roentgenogram, showing numerous calculi in the left kidney; b, intravenous urogram, showing horseshoe kidney with good function on both sides.

mandelic acid usually give good results in the treatment of bacillary and Streptococcus fæcalis infections. Other coccal forms and the Bacillus proteus are usually best treated by sulfanilamide. This latter drug is preferably withheld until it has been determined that mandelic acid has been ineffective. Occasionally, neoarsphenamine may be employed in the treatment of coccal infections which have proved resistant to other types of treatment. Approximately 40 per cent of renal calculi are associated with infection (1). All distant foci of infection should be eradicated.

Certain metabolic errors at times appear to be responsible for the formation of renal calculi. A chemical analysis of the removed calculus should always be made as this may shed light upon possible metabolic errors, especially if stones composed of cystine or urates are detected. In recent years hyperparathyroidism has been emphasized as a cause of nephrolithiasis, and vitamin deficiency has also been stressed. That these abnormalities may occasionally be directly related to the formation of urinary calculi appears to be fairly well established, but that they are a common cause of renal stones in this country seems extremely unlikely. These possibilities, however, should be considered in the treatment of each patient with urinary lithiasis as only by combined medical and surgical management will the best immediate and end-results be obtained.

Surgical aspects. As a result of widespread interest in these newer conceptions of the etiology of renal calculi, certain older, well recognized anatomic abnormalities which are frequently associated with calculi have received little consideration. Stasis caused by various types of obstructive lesions is often found to be present when stones are removed from a kidney. The ease with which infection appears in the presence of stasis and the difficulty of rendering the urine sterile under such conditions is well known.

The kidney which contains a stone often shows some evidence of pyelectasis and caliectasis. Whether the obstruction which caused this hydronephrosis is primary and the formation of the calculus secondary, or vice versa, is sometimes difficult to determine. Too often, however, it is more or less assumed that the stone is the cause of the hydronephrosis, and a careful search is not made for any possible extrinsic cause for obstruc-

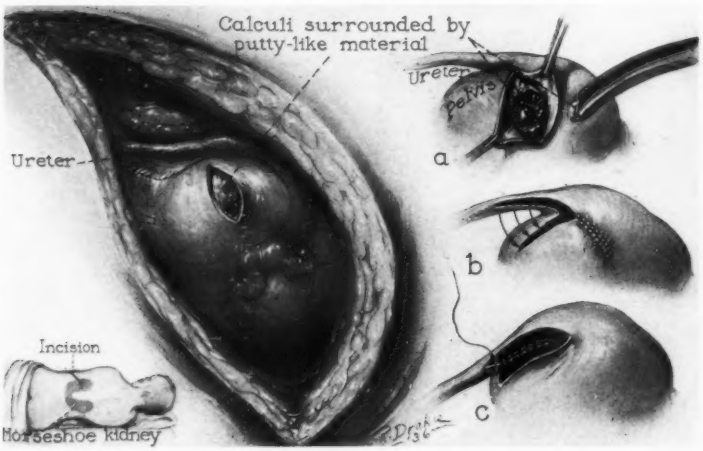

Fig. 2. Drawing made at time of operation, showing removal of calculi from renal pelvis and plastic operation on ureteropelvic juncture.

tion. Whenever a calculus is removed, the region of the ureteropelvic juncture should be exposed and examined to determine if there is any evidence of interference with free drainage from the kidney. When the pelvis is opened, the diameter of the ureteropelvic juncture can be readily ascertained by passing a catheter or curved forceps into the upper portion of the ureter. Anomalous vessels, high insertion of the ureter into the pelvis, constricting fibrous bands, or other causes of obstruction may be present. When one finds definite evidence of an organic cause for faulty drainage from the kidney, this should be corrected. If this is not done, stasis of varying degree persists after removal of stones and, not only is the possibility of recurrence increased, but damage to renal parenchyma is progressive.

Surgical treatment depends on the type of obstruction that is present. The numerous details of the conservative surgical management of obstruction in the region of the ureteropelvic juncture will not be discussed (2). Suffice it to say that the main idea of all such procedures is to establish free and dependent drainage from the renal pelvis. To accomplish this purpose it is often necessary to vary the surgical procedure according to the exact anatomic condition that is encountered. Such a plan is more desirable than endeavoring to adopt one particular surgical technique to every case that is encountered. Plastic operations on the renal pelvis or ureter can in many cases be combined with pelviolithotomy or nephrolithotomy quite satisfactorily.

If considerable infection is present it may not be advisable to carry out any procedure other than removal of the stones and drainage of the kidney by nephrostomy. Under these conditions, too extensive an operation, which necessarily involves some trauma to the renal parenchyma, might jeopardize the entire kidney by increasing the likelihood of an extensive parenchymal infection during the early postoperative period. It may therefore at times be necessary to be content with correction of the most urgent condition and subsequently to consider further operation if this is essential to continued satisfactory renal function. An illustrative case follows:

A woman, aged 21 years, registered at the clinic on October 4, 1935, complaining of intermittent pain in the left renal region of 1 year's duration. Episodes of chills, fever, dysuria, and frequency of urination had occurred. The patient's health was otherwise good. Clinical investigation revealed multiple calculi associated with a moderate degree of infection in the left half of a horseshoe kidney. The right half of the kidney seemed to be in good condition and was free of infection (Fig. 1). Operation was performed October 10, 1935.

Exploration through a left posterolumbar incision revealed a horseshoe kidney, the left half of which appeared to be in good condition except for an enlarged pelvis which contained multiple, small soft stones. The pelvis presented anteriorly, and it was noted that the ureter inserted high up on the medial side of the pelvis, a condition which obviously interfered with adequate drainage of the kidney (Fig. 2). The ureter passed in front of the isthmus which connected the two kidneys, but there was no evidence of obstruction in this region. The pelvis was opened and numerous small stones were removed. Fluoroscopic examination and a roentgenogram made at this time showed no other calculi. Ureteropyeloneostomy was then performed

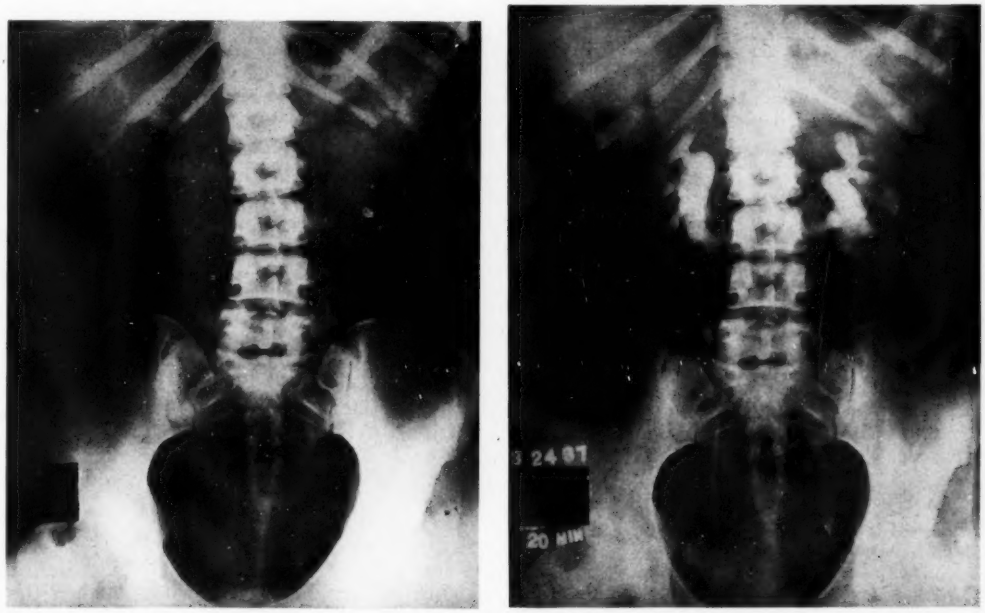

Fig. 3. a, left, Plain roentgenogram, 18 months after operation, showing no calculi in urinary tract; b, intravenous urogram, 18 months after operation, showing normal renal function and reduction in size of left renal pelvis.

at which time the ureter was anastomosed to the dependent portion of the renal pelvis. The immediate postoperative convalescence was quite satisfactory. Considerable difficulty was experienced in eliminating all infection from the left kidney and, before this was accomplished, several recurrent[1] calculi lodged in the ureter and were removed transurethrally by Thompson and Cook. Within several months following operation the urine was sterile and after this no more calculi formed. Examination of the patient, March 23, 1937, revealed a sterile urine, normal renal function, and reduction in size of left renal pelvis (Fig. 3).

OPERATION FOR RECURRENT STONES

When confronted with the necessity of removing recurrent renal calculi, operation is always more difficult than in primary cases. The kidney is firmly embedded in dense, fibrous tissue, adherent to the peritoneum on its anterior surface, and mobilization must often be accomplished by sharp dissection. A kidney which has been operated on previously and which contains recurrent calculi is never in normal condition and should be traumatized as little as possible. If complete mobilization of the kidney under these circumstances involves excessive trauma to the renal parenchyma, it may be advisable to mobilize the kidney as little as possible. It is oftentimes possible to remove stones through the pelvis without mobilizing the kidney to any appreciable extent. If this is not feasible, it may be desirable to perform nephrolithotomy in order to avoid the trauma of unnecessary mobilization. A dilated calyx can often be opened on its cortical surface and a stone removed with little damage to the parenchyma.

[1]Known to be recurrent because these calculi were composed of calcium phosphate and the original stones were calcium oxalate.

CONCLUSIONS

In general, stones may be removed from the kidney with a low initial operative mortality and with the legitimate expectation of excellent ultimate results in the majority of cases if certain general principles are followed.

Careful surgical management together with adequate and proper medical care, which include complete elimination of infection from the urinary tract and consideration of any metabolic, endocrine, dietary, or chemical abnormalities, are essential if the best results are to be obtained.

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CUTTING THE COSTAL ARCH FOR UPPER ABDOMINAL EXPOSURE

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DURING the past 2 years we have been able to obtain added exposure in difficult upper abdominal operations by cutting the costal cartilages of the left sixth and seventh ribs, and then retracting the chest wall. This maneuver has added very materially to the ease of certain high resections of the stomach and to the abdominal exposure and repair of diaphragmatic hernias.

We were, at first, somewhat hesitant to add this extra procedure to serious upper abdominal operations. Although it is generally recognized that adequate exposure of the operative field is the first principle of surgery, we have avoided any radical steps to obtain this exposure. Longer incisions, greater trauma, extra time, and increased blood loss are all factors in the production of operative shock, and must be reduced to a minimum. On the other hand, however, it is a fact that, in our experience, the increased facility of operation, after cutting the costal cartilages, overbalances any increment of shock caused by the procedure.

Attempts at increasing upper abdominal exposure by supplementary operations on the lower thoracic cage have been sporadically reported since Micheli's work on cadavers in 1895. His proposed method of turning up a wide flap including ribs, diaphragm, and parietal pleura was quickly recognized as far too radical and shocking to add to the major abdominal operation, i.e., gastrectomy, splenectomy.

Outstanding surgeons of the German school from 1898 to 1908 published less radical modifications which, in a few instances, were tried on the living patient (Mikulicz, Asthoewer, Marwedel, W. Meyer, Wiener). Most of the patients died either from the advanced malignancy of the stomach or esophagus, or from the operation.

Elevation of the left lower costal outlet as a supplementary procedure in abdominal surgery was first done in the living patient in 1894 by Asthoewer (not reported until 1903, contesting Marwedel's priority). To remove a 7 pound fibroma of the spleen in a 59 year old male he made three incisions: First, at the outer border of the left rectus muscle; second, transversely to the left to the tip of the eleventh rib; third, from the eleventh rib up over chest wall parallel to the first incision. Then he cut the eighth, ninth, and tenth ribs laterally and their fused costal cartilages medially to raise an osteoplastic flap. The patient died on the following evening. He performed a second operation in 1902, on a 45 year old male with sarcoma of the left chest wall, and used an oblique incision, from the ensiform cartilage to the tip of the eleventh rib. He divided the seventh costal cartilage near the midline and the eighth, ninth, and tenth ribs laterally in the midaxillary line. The sarcoma was inoperable, and the patient died on the seventeenth day.

By 1895 an extensive procedure for elevation of a costal flap had been worked out on the cadaver by Lannelongue and by Micheli (Tenth Italian Surgical Congress, 1895). By this method the eighth to eleventh ribs were divided laterally and their fused costal cartilages medially, forming a large flap with its base upward, and including ribs, diaphragm, and parietal peritoneum. It was widely condemned by surgeons as too bloody and dangerous a supplementary procedure (Kelling (6), Marwedel) to be carried out in the living patient.

Mikulicz raised a costal flap in 2 patients (October, 1896, and August, 1899) for resection of cancer of the cardiac stomach and esophagus. Death occurred 30 hours and 24 hours later, respectively (reported in detail by Gottstein). Similar to the method described above he raised a large costal flap by dividing the fused costal cartilages medially and the ribs laterally up to the sixth interspace, using multiple skin incisions in 1 case, and a U-shaped skin incision in the other.

Kelling attempted to avoid cutting the thoracic cage, and sought exposure of the subdiaphragmatic area by allowing the pelvis and legs to hang vertically over the end of the operating table. The upper abdominal viscera were thus pushed forward and exposure was further aided by division of the suspensory ligament of the liver. He believed this to be a less shocking procedure, and an easy position to obtain.

Marwedel many times on the cadaver (1901–1903) raised a cartilaginous flap by division of the costal cartilages close to the sternum, and also

close to the costochondral junctions. If a wider flap was desired he advised more lateral division of the ribs themselves. He did this quickly and with a successful outcome on a 20 year old girl with a stricture of the lower esophagus. The wound healed *per priman* and when examined 7 weeks later there was firm fibrous union of the costal cartilages.

Willy Meyer, in 1904 and 1905, had two occasions to resect the costal arch, enabling him more conveniently, first, to explore an esophageal stricture, and, second, to resect a huge sarcomatous spleen. He used a U-shaped incision in 1 case, and a combined longitudinotransverse incision in the other, with division of the fused cartilages medially and laterally near the margins of the seventh, eighth, ninth, and tenth ribs. Both patients made good recoveries. He also suggested division of the ribs more laterally for wider exposure.

Wiener, in 1908, used multiple skin incisions and raised a left costal flap in a 45 year old woman with cancer of the cardiac stomach and esophagus. The pleura was injured, and resutured. Emphysema of the chest wall and neck developed rapidly on the first and second days, and lasted 2 weeks. The patient died after secondary operation for removal of the cancer 30 days later.

Between 1908 and 1929, a period of great advances in surgery, no further reports could be found. H. W. Meyer, in 1929, reported 2 cases: 1 in which he helped W. Meyer in 1924 turn up a left costochondral flap to facilitate anterior gastroenterostomy high near the cardia, in a patient with totally obstructing, inoperable carcinoma of the pyloric stomach. In the second patient, who had a spleen lacerated by a gunshot wound, H. W. Meyer raised a left costal flap by dividing the fused seventh, eighth, and ninth cartilages close to the manubrium sterni and by then dividing the outer ends of the seventh to tenth costal cartilages close to the bony ribs. The patient made a good recovery. Meyer recommends wider use of this chondroplastic resection of left costal arch.

Bickham describes an essentially similar method of temporary resection of the left costochondral arch with variations described as the Baudet-Navarro and Sonnenberg techniques.

Every attempt should be made to increase the reasonably safe operability of especially high lesions of the upper abdomen. One of the many disappointing pathologic findings of ulcer or cancer of the stomach is often the high extension of the lesion, whether benign or malignant, on the lesser curvature or fundus, even to encroach on the lower esophagus. Often one of the chief decisions against operability lies in the inaccessibility of the area. Or, if the operation is carried out, usually great difficulty in exposure is encountered, due first to the surgical anatomy of the stomach. The stomach, when empty, lies far back in the abdominal cavity, beneath the left lobe of the liver, and in front of the pancreas. The cardiac portion lies high under the left costal arch, beneath the left lobe of the liver. The cardiac orifice lies beneath the left seventh chondrosternal articulation, 1 inch to the left of the sternum. The gastrohepatic mesentery may often be short, thickened, and inelastic, especially toward the proximal end of the stomach. This renders especially difficult the mobilization of the cardiac end of the stomach, and necessitates carrying out the anastomosis deep in the abdomen, high under the costal arch.

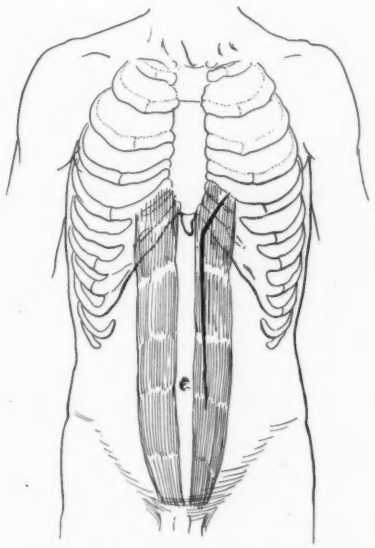

Fig. 1. Outline of the incision. Note that the upper end of the incision turns sharply to the left, cutting some of the rectus muscle fibers transversely, or obliquely, and going through the costal arch. Note also the extension of the incision well down the abdomen below the umbilicus. Muscle retracting incisions we have preferred.

Furthermore, in repair of diaphragmatic hernia, the transabdominal approach has been preferred by many, and we have found it satisfactory in some cases. One of the chief difficulties, however, has been exposure in the region of the hernial opening in the diaphragm, so that after reduction of the hernia, a firm closure of the diaphragmatic hiatus may be accurately carried out.

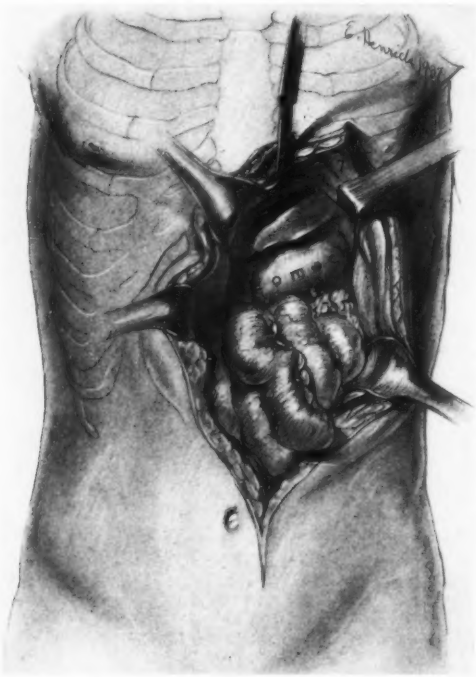

Fig. 2. Cartilages of the sixth and seventh ribs have been cut, and the chest wall below has been retracted upward and outward. Care must be taken not to cut the internal mammary artery, or enter the pleural cavity.

To obtain an increased exposure, and thereby increased safety in carrying out these operations, we have added to our technique the following measures: (1) Section of the fused left sixth and seventh costal cartilages, and (2) mobilization of the left lobe of the liver as suggested by Grey-Turner. We have used these procedures on two occasions for nearly total resection of the stomach, and on two occasions for the repair of diaphragmatic hernia. Our experience and the good results obtained in these patients have demonstrated to us the usefulness of the maneuver, and its possibly wider applicability in surgery of this region. It is especially helpful in obese, barrel-chested patients, and in those with a narrowed costal arch and smaller operative field.

We have had no hesitation in using this method wherever added exposure might increase the safety of the operation. We have had no particular difficulty with it, except possibly the rare presence of ossification of the costal cartilages in the elderly patient. In such an instance, bone forceps would be required instead of a simple section of the fused cartilages with the scalpel. In 1 case we entered the pleural cavity, but immediate suture of the hole was made, and no difficulty followed.

The technique which we have adopted in these cases is as follows: We prefer a small, left rectus, muscle retracting incision, through which the abdomen is first explored. If we determine that the lesion is operable, the incision is enlarged downward well below the umbilicus, and upward to the edge of the left costal outlet. Graham gains much added exposure by carrying the incision well up over the chest wall, at least 2 inches above the costal margin, through all the soft tissues. He comments on the increased exposure obtained by this simple, generous upward extension of the abdominal incision, thus allowing better retraction of the rectus muscle and fascia. With this we are in agreement, and in most cases this gives all the exposure required.

In certain cases, however, it is apparent that further exposure is desired. The skin incision at the upper angle is then deflected laterally 45 degrees and is carried through the skin and subcutaneous tissues upward and outward for 2 inches over the left costal cartilages (Fig. 1). This incision is carried deep across the medial attachments of the left rectus muscle, thereby exposing clearly the usually fused cartilages of the sixth, seventh, and eighth ribs. The left hand is carried into the abdomen, beneath the left costal outlet, to outline the position and height of the underlying diaphragm. With the ordinary scalpel the left sixth and seventh fused costal cartilages are cleanly divided, 1 inch to the left of the sternum. The incision is carried not perpendicularly through the cartilages, but rather obliquely upward toward the left midclavicle in direction (Fig. 2).

Care must be taken to avoid the underlying internal mammary artery; when this vessel is cut it can best be controlled with suture ligatures. The underlying muscle of the diaphragm will usually be thick, so that possible division of some of the muscle fibers will give warning to guard against further incision and injury to the closely adjacent pleura. If the pleura is opened, it must be closed at once by pack and suture.

Having completed the procedure, the left lower thoracic cage is gently retracted laterally. This gives an amazing increase in the ease of approach to the upper end of the stomach. Mobilization of the left lobe of the liver is next carried out, if still greater accessibility is needed. This is done according to the technique described by Grey-Turner. The hand is passed up over the left lobe, retracting it downward, thereby bringing into re-

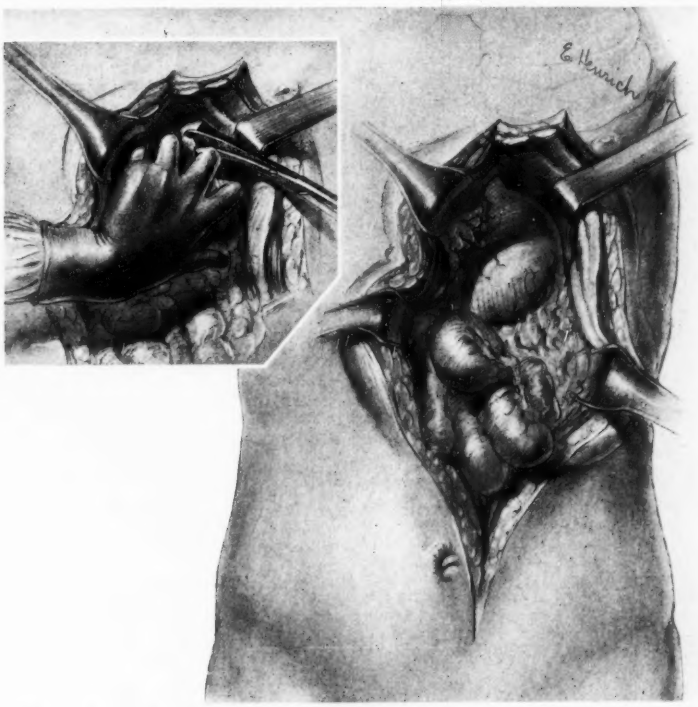

Fig. 3. Insert shows cutting the lateral ligament of the left lobe of the liver. The main drawing shows the left lobe of the liver retracted after the ligament is cut; the left chest wall elevated and retracted after the sixth and seventh costal cartilages are cut; the greatly improved exposure of the diaphragm, and the cardiac portion of the stomach is demonstrated.

lief the left lateral ligament of the liver (Fig. 3). This attachment is avascular and may be divided freely, with generous retraction of the left hepatic lobe toward the right abdomen. The deep areas of the wound are protected with gauze; retractors are put in place; and a wide exposure of the upper abdomen is thus obtained.

On completion of the operation, the left lobe of the liver is gently replaced, without suture of the divided ligament. The left lower thoracic cage is allowed to fall into its normal position, and no attempt at reunion is made by drilling or suturing the cartilages. The posterior and anterior rectus sheaths are closed separately, and a small rubber dam drain is placed in the subcutaneous areas at the upper and lower angles of the incision.

Although the number of cases in which this procedure has been used by us is relatively few, no complication related directly to the procedure has been noted. There has been no increased hospitalization nor morbidity attributable to it. There has been no evidence of unusually delayed wound healing, necrosis, drainage, or suppuration.

CASE 1. Mr. A. W., a 54 year old Russian male, was operated upon (H.M.C.) on November 11, 1936, for a large indurated malignant appearing ulcer measuring 5 by 3 by 3 centimeters and lying high on the lesser curvature of the stomach. An upper left rectus incision was made. On exploration there were found no metastases. A high gastric resection was carried out so as to leave one-fifth or less of the stomach, which was anastomosed to the jejunum according to the posterior Pólya method.

During the anastomosis, which lay so deep and high in the abdomen that safety hinged on added exposure, the incision was enlarged upward and obliquely to the left, cutting through the left rectus sheath and muscular attachments. Thus the fused sixth, seventh, and eighth costal cartilages were clearly exposed. The latter were then cleanly incised with the scalpel, with care to avoid injury to the pleura. The left lower thoracic wall could then be retracted well to the left without force. The anastomosis was

Fig. 4. Photograph of patient having very high resection of the stomach with cutting of the costal arches 6 months previously.

completed with relative ease. The incision was closed in layers without special attention to the cut costal cartilages, which were allowed simply to fall back into position. A small rubber dam drain was laid down to the cartilages at the upper angle of the incision.

The patient was given a transfusion, made an uncomplicated recovery, and left the hospital on the sixteenth day with primary wound healing. The pathologic report showed gastric ulcer and no malignancy. At examination 1 month and 4 months later, respectively, the wound was solidly healed.

CASE 2. Mr. L. M., a 58 year old Syrian male, was operated upon (H.M.C.) on April 22, 1937, for carcinoma high on the lesser curvature of the stomach, attached posteriorly to the pancreas. There were no evident metastases. High subtotal gastrectomy was done with a posterior Pólya anastomosis. In order to gain further exposure and to complete the high anastomosis, the approach to which was very difficult, the fused sixth and seventh cartilages on the left side were cut. The anastomosis was then completed without incident. The wound was closed in layers, supplemented by retraction sutures through the entire abdominal wall. The patient was given a transfusion, ran an afebrile course (highest temperature 99.2 degrees on the third day), and was discharged on the twentieth day with primary wound healing. Examination at 1 month and 6 months (October, 1937), respectively, showed the wound to be strongly healed (Fig. 4). The pathologic report showed adenocarcinoma grade II–III with no regional metastases.

CASE 3. Mr. R.V.L., a 52 year old American male, complained of indigestion for 1 year, and vomiting after meals for 3 months. Clinically and roentgenologically he was thought to have a diaphragmatic hernia. On March 12, 1937, a left temporary phrenic nerve interruption was done. Five days later transabdominal exploration (H.M.C.) was carried out. Exposure was obtained at the outset by dividing the fused sixth and seventh costal cartilages just to the left of the ensiform process, and by dividing the diaphragmatic attachment of the left lobe of the liver, according to the method described by Grey-Turner.

A thin-walled diverticulum, about 7 centimeters in diameter, of the lower third of the esophagus was found. There was no diaphragmatic hernia. The esophageal hiatus was enlarged, and the diverticulum freed from pleura and diaphragm. During the procedure the left pleural cavity was opened and at once resutured. Just at the close of the dissection a hole was torn at the junction of the esophagus and the diverticulum. The diverticulum was, therefore, brought below the diaphragm and marsupialized by suturing it to the skin at the upper angle of the wound. A large cigarette drain was placed down to its base and the abdomen was closed in layers. Closed thoracotomy drainage of the left lower chest was then carried out, followed by transfusion.

Following operation the patient did well for 6 days, when he developed signs of bronchopneumonia in both lung fields. On the tenth day gastrostomy, under local anesthesia, was done for feeding. He died on the twelfth day following operation. Autopsy showed bilateral bronchopneumonia and localized peritonitis in the upper abdomen. We could not associate any of his troubles with the incision we had used.

CASE 4. Mrs. N. H., a 35 year old American housewife, was operated upon (H.M.C.) on July 28, 1937, for diaphragmatic hernia. The left phrenic nerve was crushed 2 days previously to immobilize the left diaphragm. An upper left rectus muscle splitting incision was made. The left sixth and seventh costal cartilages were cut close to the midline and the ribs were retracted laterally. The herniated stomach was reduced into the abdomen. The 5 centimeter slit-like opening at the esophageal hiatus was closed securely with heavy silk. The abdomen was closed in layers without special attention to the costal cartilages. Recovery was uneventful, with primary wound healing, and the patient was discharged on the fifteenth day after operation.

Examination 7 months later, February 10, 1938, showed the wound strongly healed, and x-ray examination showed no recurrence of the hernia. Intermittently she had noticed slight tenderness at the upper angle of the incision which had been at no time severe.

SUMMARY

Attention has been directed to the technical usefulness of a relatively simple maneuver for obtaining added exposure in surgery of the upper abdomen. Avoidance of the more radical "costal flaps" in favor of this simplified procedure has been advocated. The help obtained from this added maneuver is shown in the 4 cases reported herewith.

CONCLUSIONS

1. Restricted exposure high in the upper abdomen may reduce safety of operation.

2. Elevation of a left "costal flap" as a supplementary procedure in abdominal surgery has been reported sporadically since 1895. Because of the added trauma involved it has met slow acceptance by clinical surgeons.

3. Mobilization of the left lower costal outlet may be simplified, without recourse to a complete "costal flap," in the usual case by cutting the sixth and seventh costal cartilages.

4. The procedure has been used in 4 patients during the past 2 years, with technically gratifying results. Added operating time and shock were minimal, and safety of suture lines was greatly increased.

5. The hazards, namely, tearing of the pleura and hemorrhage from the internal mammary artery, should be recognized, that they may be avoided.

6. The technical steps are described and illustrated in 4 patients.

7. Mobilization of the left lobe of the liver as described by Grey-Turner was used to complete the exposure in 1 patient, and the method is reviewed technically here.

8. No complication, delayed wound healing, or morbidity resulted from the cartilage-cutting procedure in these 4 patients.

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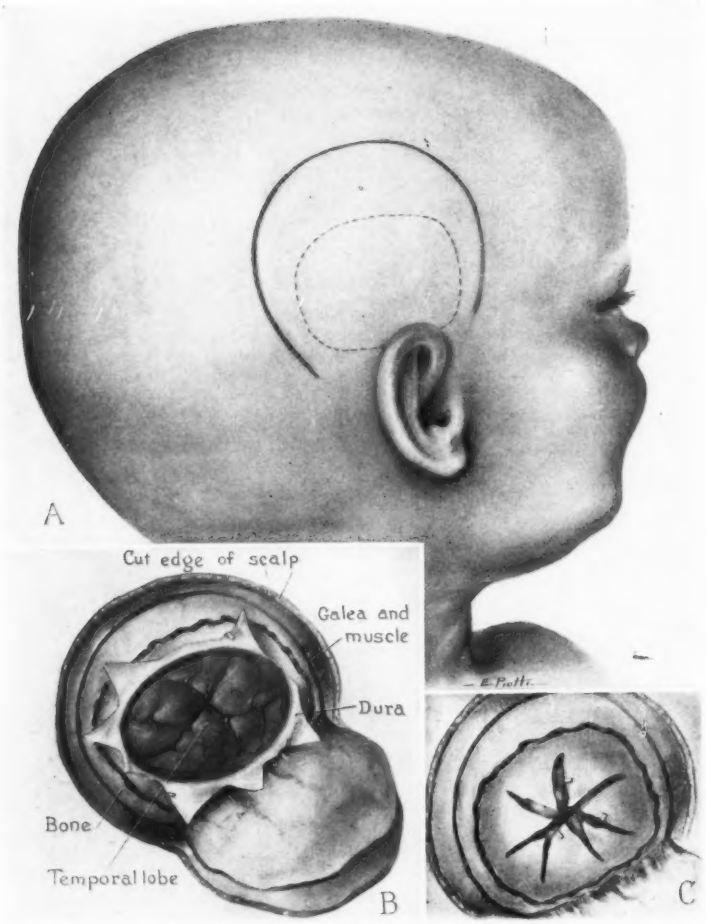

Fig. 1. A, Incision and extent of bony defect; B, margin between layers; C, dura as left before closure.

A Modified Subtemporal Decompression for Use in Infants and Children.—Franc D. Ingraham.

A MODIFIED SUBTEMPORAL DECOMPRESSION FOR USE IN INFANTS AND CHILDREN

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IN the treatment of neurological disorders in infants and young children, one is occasionally faced with an urgent need of increasing the capacity of the cranium. In general the skulls of young infants enlarge spontaneously by rapid separation of the sutures. The elasticity of the dura being distinctly limited, however, operation may be necessary in order that the brain may not be compressed by it. In children between the ages of 2 and 12, separation of sutures occurs at an increasingly slow rate, and surgical decompression may be badly needed.

The operation described by Cushing[1] in Ochsner's *System of Surgery* in 1920 was suggested primarily to relieve discomfort and save vision in patients with intracranial tumors which could not be localized. It has served its purpose satisfactorily in the hands of many operators and has long been the procedure of choice in adults and in older children with well developed bones and muscles. It has been apparent on numerous occasions, however, that the increase in the capacity of the cranium achieved by this technique as employed in very young patients has been so slight as to be scarcely worth while. In 1936, Cone and Penfield[2] described their method of performing a subtemporal, as well as suboccipital, myoplastic craniotomy by which they gain a relatively large decompressive opening. It has the advantage of permitting rapid exploration which is not possible through the muscle splitting incision. However, the success of this procedure depends on a well developed temporal muscle which can be sutured to the bone, thus precluding its use in the group of patients referred to here. The very simple modification of technique described here has proved so useful that it has seemed worth while to suggest its more general use.

As shown in the sketch, the scalp is incised as for a small bone flap. The right-side is used in definitely right handed children and in infants so young that it is not clear which is the dominating

From The Surgical Service of The Children's Hospital and The Department of Surgery, Harvard Medical School.

[1]Cushing, H., in Ochsner, A. J. Surgical Diagnosis and Treatment. Philadelphia: Lea and Febiger, 1920.

[2]Cone, W., and Penfield, W. Subtemporal and suboccipital myoplastic craniotomy. Arch. Neurol. & Psych., 1936, 35: 1.

Fig. 2. G.N., aged 2 years, 1 month, 6 months after bilateral subtemporal decompression.

Fig. 3. J.N., aged 5 years, 2 years after bilateral subtemporal decompression.

hemisphere. The initial incision is carried down to the superficial fascia overlying the galea, and the scalp thus freed is retracted so that the next step may be made accurately. Incision is then made through the galea down to the bone about 1 centimeter from the cut edge of the scalp. This layer, including the attachment of the temporal muscle, the muscle itself, and fascia, is then reflected with the scalp, leaving a relatively large area of bone exposed. A burr hole is made and the bone rongeured away only throughout the lower portion of the wound. An opening of about 4 by 5 centimeters can be made even in very young infants. Thus there is left a broad ledge of bone between the scalp incision and the actual decompression. This relatively large exposure is necessary to insure firm closure of the temporal muscle attachment, the decompression itself being limited to the area covered by the muscle. The dura is opened in the usual way by a stellate incision well within the limits of the bone defect. Closure is accomplished by very careful suture of periosteum, galea, and superficial fascia in one layer, except in the lower portion of the wound where the temporal muscle can be closed separately. This must be done very accurately, but when so done, results in firm union with essentially a new attachment of the temporal muscle. The skin is then closed as usual. Black silk sutures are used throughout.

This operation obviously takes longer than the simpler linear incision and muscle splitting exposure, but is tolerated very well, and the obvious advantage of the additional room obtained usually more than offsets the undesirability of increasing the length of the operation.

This operation has been carried out with considerable satisfaction in numerous conditions other than intracranial tumors in infancy and childhood. It may be of interest to mention lead encephalopathy with edema in which there is often an urgent need for decompression. In fact, this procedure has recently been carried out with good result as a preventive measure in such a patient when the pressure and the total protein of the cerebrospinal fluid were beginning to rise. Bilateral operation is frequently necessary in these cases, as it usually is in oxycephaly and scaphocephaly with increased intracranial pressure. This modification of technique is not suggested for exploration and is obviously less useful than the Cone-Penfield procedure except in very young patients in whom fairly wide decompression is needed.

THE MECHANICAL PROBLEM OF UNMODIFIED BLOOD TRANSFUSION

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THE therapeutic indications for blood transfusion are well established and have been adequately reviewed and emphasized by Bishkow, Blain, Miller, Doles, and others. Methods of blood typing and testing of blood compatabilities are well standardized (9), assuring excellent protection to the patient. It is the opinion of Bernheim, Bishkow, Field, Heineck, Herr, and others that if blood transfusion is indicated, unmodified blood is usually preferable. Blain, Brines, Brooks (3, 6, 7), Head, Unger, Scannell (20), Lindemann, and many others have made definite contributions to solving the problem of the transfer of unmodified blood from donor to recipient, but in spite of these efforts, much is to be desired in the actual solution of the problem.

The instruments designed by Unger, Scannell (20), Brines, and others have, in the hands of the designers and of expert transfusionists, produced very satisfactory results, but in the hands of less expert operators, have frequently been disappointing. Because the occasional operator so frequently fails in the transfer of the desired quantity of blood, he is quickly prejudiced in favor of the more easily accomplished and almost universally successful citrate method. Lewisohn (15), the originator of the citrate method, ably defends (16) it as equivalent to unmodified blood transfusion, but Bernheim, Bishkow, Field, Heineck, and Herr maintain that citrated blood is not as valuable and carries a greater hazard of detrimental reaction.

Every surgeon who uses unmodified blood transfusion will fully appreciate its difficulties and disappointing complications. The slightest delay in accomplishing successful venepuncture of donor or recipient will almost certainly result in plugging of one of the needles, thus interrupting the operation before the desired amount of blood has been transferred. Any delay at any time after starting the first venepuncture is disastrous. Needles or conduits plug with fibrin, syringes stick, so that apparatus must be frequently rinsed or changed. If a single time-consuming incident occurs, the operation is likely to be a failure.

Clotting was the cause of discouragement in the early attempts at blood transfusion (Blundell), and fibrin precipitation is still an unsolved problem. Factors promoting fibrin precipitation are rough surfaces, slowing of the blood stream, injury to cellular elements, stagnation of blood, and time. In every syringe or pump device. one point of positive and continuous stagnation is the point of contact between the piston end and the blood column. Here precipitation quickly occurs, and from this nidus quickly spreads over the end of the plunger to drag against the walls of the syringe. With the forward movement of the plunger, the fibrin film drags between the plunger and the barrel of the syringe, macerating the cellular elements, thus providing an essential element of rapid fibrin precipitation. With this stimulus, fibrin quickly precipitates on the syringe barrel. With the forward excursion of the plunger, the first, thin fibrin film is scraped off in small shreds to be liberated in the blood stream as minute emboli or, if larger, to plug the needle in the recipient's vein. With the maceration of the first cellular elements between syringe plunger and barrel, fibrin precipitation accelerates and the film quickly thickens to the point of embarrassing or entirely inhibiting the movement of the plunger. To prevent positive freezing of the syringe, rinsing or changing is necessary, and this delay promotes precipitation in the various channels of the instrument.

If the supply from the donor is slow, the time element becomes a factor, but efforts to hasten the flow by increased suction may result in air filtration between plunger and barrel of the syringe with the resulting accumulation of air bubbles. The presence of air further promotes coagulation and presents a constant hazard of air embolism.

Believing that any contribution to the simplification of transfusion would be a stimulus to the popularization of this valuable therapeutic procedure, study of the subject was begun in 1927. The first approach to the problem was an effort to shorten transfusion time and to minimize the liability of coagulation by establishing a continuous flow of blood between donor and recipient. This was accomplished by the use of reciprocating syringes, one syringe filling as the other discharged, thereby establishing a continuous

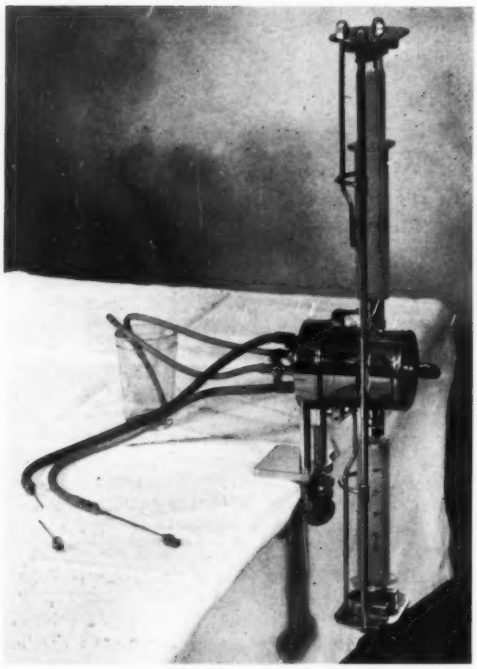

Fig. 1. The instrument in position for the downward thrust of the traveling frame to which the pistons are attached. The upper syringe is in position for discharge to the recipient.

flow of blood with no areas of intermittent or total stagnation. This result has also been accomplished in a similar manner by Brines, Janes, and by the Martin modification of the Unger instrument. Record syringes were used, the plungers of which were supplied with an irrigating mechanism to prevent freezing. The reciprocating syringe instrument design was completed and constructed in 1930 and, in the hands of the designer, worked very well. It was not, however, a satisfactory contribution to simplicity, as the irrigating set-up was too complicated. Also, the double channel valve which connected the two syringes had elements of danger, in that it was possible for the operator to become confused and reverse the blood stream. For these reasons the instrument was not at that time considered as suitable for general use.

The instrument which is now to be described retains the reciprocating syringe principle and we believe embodies elements of simplicity, security, and convenience not previously reported. The syringes are mounted radially upon a hub rotatably assembled upon a spindle, the operative position being vertical. The spindle is channeled with an intake port communicating with the mouth of the dependent syringe and with a discharge port communicating with the mouth of the upper syringe. The instrument is supported by a frame clamped upon an arm board or table. The pistons are attached to a traveling frame and move simultaneously so that, with the downward stroke, the upper syringe discharges to the recipient while the lower syringe fills from the donor. At the completion of the downward stroke, the latch holding the hub is automatically released and the syringes are rotated through a half circle, thus bringing the filled syringe to the top and the empty syringe to the lower position. In this position, the automatic latch again locks the hub and the downward thrust of the frame carrying the plungers is repeated. The weight of the traveling frame with pistons attached assists in this downward thrust and is sufficient at the beginning of the operation to keep saline trickling through the needle into the vein of the recipient while the operator is engaged in completing the venepuncture of the donor. Also during the operation, there is a continuous gravitational assistance as the blood from the donor flows downward into the dependent syringe while the blood from the upper syringe flows downward into the vein of the recipient. This gravitational pull assists in minimizing the propelling pressure and suction required, thereby protecting the cellular elements of the blood from injury by too great an alteration of negative and positive pressure.

We believe that we have a unique improvement in the syringe used which may be adapted to any syringe method. The syringe is the standard Luer with hollow piston, but the end of the piston is not closed, thus making the cavity of the piston continuous with the cavity of the syringe. Near the open end of the piston, shallow, spiral grooves on its outer wall communicate with the cavity of the piston through small perforations in its walls. In preparation for the operation, the instrument and all channels are filled with 1 per cent sodium citrate solution. This is subsequently replaced with saline before the operation is begun, but the citrate solution in the pistons remains in position. This converts the piston into a fluid plunger with a citrate fluid contact between the end of the plunger and the blood column. Air is easily evacuated from the pistons by an upward and downward stroke which evacuates the air from the lower syringe when the hub is rotated, and the upward downward stroke is repeated to

evacuate air from the syringe just rotated into the dependent position. The upward stroke is never used during transfusion and is used only for purposes of irrigating the syringes or, as just described, in evacuating air from the plungers of the syringes preparatory to the beginning of the transfusion. When the preparation is completed, the plungers of the syringes and the grooves of the plungers are filled with citrate solution.

The fluid contact between the piston end and the blood column eliminates the most potent point of fibrin precipitation, and with each excursion of the plungers the citrate filled grooves on the pistons wipe the syringe barrels with citrate solution, thereby inhibiting fibrin precipitation. The standard Luer Lok is used to attach the syringe to the hub ports and the piston ends are anchored to the traveling frame by a slot lock so that either syringe can be quickly and easily removed and substituted.

The instrument is easily cleaned as all channels are straight. It is simple enough to be easily comprehended by a novice, while proficiency in its use is quickly acquired. The downward stroke alone is used during transfusion and the instrument will not reverse the blood stream upon the upward stroke, as the channels are not in contact and the automatic latch does not release with the up stroke; so the danger of contaminating the donor with blood from the patient is absolutely eliminated.

The harassing air bubble which will occasionally sneak by pistons or through connections can be entirely ignored, as it rises to the top of the fluid-filled plunger in the discharge syringe which is in the upper position so that the bubble is far removed from any danger of being forced into the patient's circulation. The same is true of oil, hence it is possible to lubricate the syringes and plungers with citrated vaseline, thereby further inhibiting the precipitation of fibrin upon the syringe barrel without any danger of oil droplets entering the circulation. The air bubble, instead of being a hazard, may even be beneficial in displacing downward some of the citrate solution in the plunger, thereby refreshing the citrate concentration at the fluid blood contact at the end of the plunger. The amount of citrate which may mingle with the blood at the citrate blood contact is very trivial and would not exceed 10 cubic centimeters of 1 per cent solution or 1.5 grains. The precipitation of fibrin may be further inhibited by the use of a chilled citrate solution, or if the small amount of citrate is undesirable, chilled saline may be used instead of the 1 per cent citrate solution.

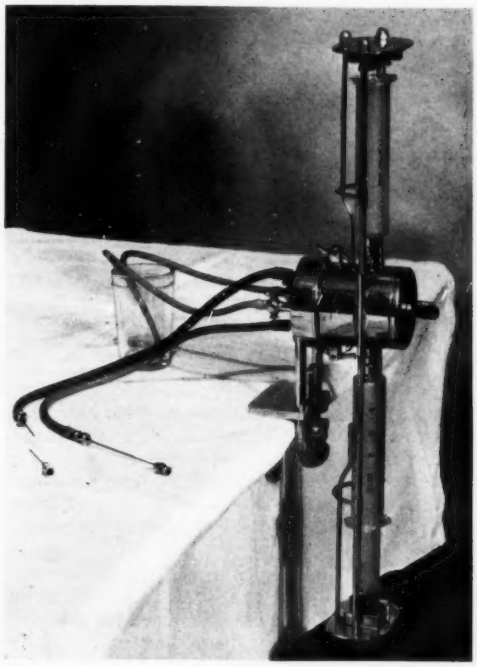

Fig. 2. The instrument at completion of the downward thrust with the discharge syringe empty, the lower syringe filled from the donor, the automatic latch released preparatory to rotating the syringes about the spindle.

The instrument is adapted to any standardized technique such as described by Christopher. Before sterilization, the plungers of the thoroughly cleansed instrument are lubricated with sterile vaseline, preferably carrying 1 per cent sodium citrate. Steam pressure sterilization is preferable. The donor and recipient are placed on parallel cots or operating tables with arm boards or an arm table extending between them. The entire arm of each is thoroughly cleansed and sponged with alcohol before being placed on the sterile draped arm board. The forearm and hand of both donor and patient are now covered with sterile drapes. A tourniquet is applied to the recipient's arm near the axilla and a blood pressure cuff to the donor. The sterile instrument is firmly clamped to the margin of the sterile draped arm board or table and the ends of all tubes are placed in a container holding 1 per cent sodium citrate solution. By operating the instrument, all the channels, syringes, and plungers are filled with the citrate solution. The end of the tube to the donor

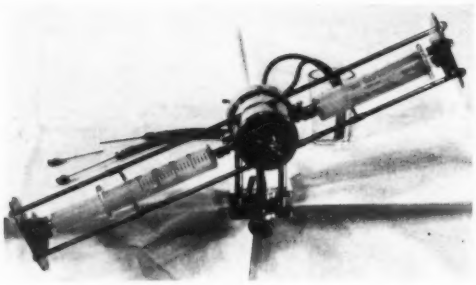

Fig. 3. The instrument in the act of rotating the syringes through a half circle.

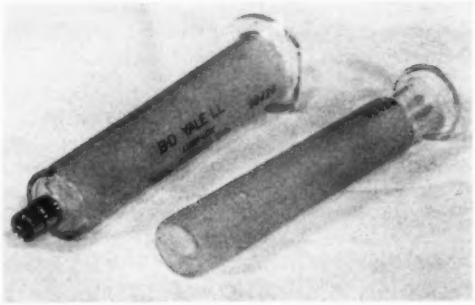

Fig. 4. The modification of the plunger in which the end of the plunger is open, making the plunger cavity continuous with the syringe cavity. Also showing the grooves upon the plunger which communicate with the plunger cavity through perforations at the upper extremity of the grooves.

is now placed in normal saline solution and the instrument is operated until all channels and syringes are rinsed with saline, the syringe plungers still being left filled with the citrate. The citrate basin is removed and all tube ends are placed in the saline basin. Preparation is now completed to proceed with venepuncture of recipient and donor.

The vein of the recipient is punctured first and the recipient tube is attached to the needle or cannula. The instrument is rotated so that the saline filled syringe is in the upper position. The tourniquet on the arm of the patient is loosened or removed and saline slowly flows into the vein of the patient, propelled by weight of the pistons and the frame, thus automatically lavaging the needle in the vein of the patient while the operator proceeds with the venepuncture of the donor.

With this routine there is no time for blood to stagnate in needles or tubes and the operation is given a propitious start.

During the transfusion the pressure on the arm of the donor is maintained at a point just below his diastolic pressure. At intervals of 1 minute or after each 100 cubic centimeters of blood transferred, the instrument is rinsed with saline (by opening the irrigation cocks and moving the plunger frame upward and downward). When the desired amount of blood has been transferred, pressure is released from the arm of the donor, the needle or cannula is withdrawn and placed in the saline basin, and the operation of the instrument continued until all blood in the instrument is discharged into the recipient.

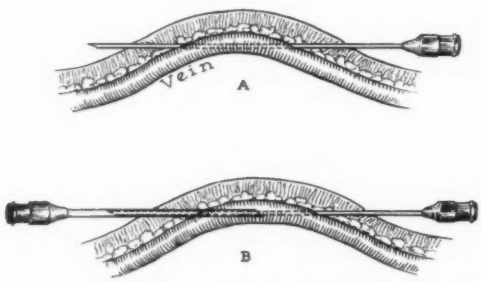

Fig. 5. A, left, Diagrammatically showing longitudinal transfixation of the vein. B, Diagrammatically showing venepuncture, the transfixation needle being used as a stilet guide.

After the needles or cannulas are removed, sterile dressings are applied. The instrument is thoroughly rinsed and immediately cleansed preparatory to resterilization.

Scannell (21) warns against the danger of contaminating the arm of the donor and recommends puncturing the vein of the donor first. It must be remembered that transfusion is a surgical procedure and that aseptic technique must be maintained. If contamination occurs in the venepuncture of the patient or if the vein must be dissected, then change of gloves, instruments, and drapes must be made before venepuncture of the donor is attempted. It frequently happens that the veins of the patient are small or collapsed and difficult to puncture, and the operation will be much expedited if connection is first established with the veins of the patient.

A most important factor in successful transfusion is expert and expeditious venepuncture. The writer has found longitudinal fixation of the vein a valuable help in venepuncture. By this method much larger needles may be used and dissection of the vein and the use of cannulas are seldom required.

The puncture is made painless by a small novocain wheel at 2 points over the vein about 1.5 inches apart. With a small gage needle, the vein is picked up and punctured through one of these wheels. The needle is then passed along in the vein and out through the second wheel, after it traverses the vein for about 1 inch. The large transfusion needle is introduced into the vein, the transfixing needle being used as a stilet guide. The vein is punctured with the point down and the needle is passed into the vein until resistance is felt where the small transfixion needle emerges from the vein. Both needles are left in position until all preparations for making connection are completed, when the transfusion needle is slightly withdrawn and rotated until the point is up and the bevel toward the lumen of the vein; then the transfixion needle is withdrawn and connection is completed as blood appears at the end of the puncture needle.

In very small, collapsed, or deeply buried veins, where dissection of the vein becomes necessary, longitudinal fixation greatly expedites the introduction of the cannula. When the vein is exposed, it is transfixed longitudinally as described. With the fixation needle as a guide, a nick is made in the vein under the needle and the cannula is quickly inserted, the fixation needle being used as a stilet guide.

SUMMARY

1. The indications for blood transfusion are well established and the technique for testing blood compatabilities is well standardized, but the problem of transferring unmodified and uninjured blood from donor to recipient presents a field inviting further research.

2. Fibrin precipitation is the principle factor in the mechanical problem of unmodified blood transfusion.

3. A new instrument is described which presents an approach to the solution of the mechanical problem.

4. The instrument described lessens the incidence of fibrin precipitation by (a) continuous and rapid flow of blood from donor to recipient; (b) shortening of the transfusion time; (c) by providing a citrated fluid contact between syringe piston and blood column.

5. Technique of venepuncture by longitudinal fixation is described.

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PERFORATION IN GASTRIC CARCINOMA

A Study and Report of 133 Cases

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THE opinion seems to prevail that perforations in carcinomatous stomachs are rare. Two cases of frank perforation encountered within a few months prompted us to make a study of all cases of carcinoma of the stomach which had been admitted to Cook County Hospital and Wesley Memorial Hospital during the past 12 years (1925–1937). In this period 3,289 patients were admitted. There were 133 cases (Table I) in which perforation had occurred. In 66 cases, or 49.6 per cent, diagnosis was confirmed by autopsy; in 45 cases, or 33.8 per cent, the diagnosis was substantiated by surgery; in 5 cases, or 3.8 per cent, diagnosis was established at operation and later confirmed by autopsy. Thus, in 116 cases, or 87.2 per cent, of this series the diagnosis was confirmed. There were 17 patients who were not subjected to surgery nor did they come to autopsy, but they had symptoms and findings that were characteristic of perforated gastric carcinoma. These somewhat questionable ones are included in this survey. The incidence of perforation of gastric carcinoma in our series is 4.04 per cent, which does not differ greatly from previous reports (6, 7, 9). The question may be raised that these figures are entirely too low because, of the total deaths in the 2 institutions, only about 20 per cent come to autopsy. This low rate of postmortem examinations provokes the feeling that if it had been possible to examine all cases of carcinoma of the stomach, the percentage of perforations might possibly reach a much higher figure.

A review of the literature reveals only a few reports (1, 2, 3, 8, 14, 17, 23) of any considerable series of cases of gastric carcinoma with perforations. They are mostly statistical and in many instances no adequate study has been made of the relative frequency of various symptoms and findings as an aid in establishing an antemortem diagnosis. In reporting our series of 133 perforations we were of the opinion that something might be added to our knowledge of this phase of the subject.

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SEX

Of the 133 cases studied, 116 were males and 17 were females (Table II). This preponderance in males may be explained by the higher incidence of gastric malignancy in the male (12) and also by the fact that men are subjected to greater physical exertion and trauma. Many perforations occurred during strenuous effort (11).

AGE

Wahl (21) states that peptic ulcers usually perforate before the patient has reached the age of 40 while gastric carcinomas perforate after the age of 40 has been reached by the patient. In our series the average age for patients with carcinoma perforation was 53.7 years, the youngest being 27 and the oldest 80. For 17 females, the average age was 49.2 years and for the 116 males, 53.9 years.

TYPES OF PERFORATION

We have grouped the cases of perforation into the classical type and the obscure type (Table III). All patients who suffered a sudden, stabbing pain in the abdomen with subsequent findings of perforation, or those in whom perforation into the general abdominal cavity was proved by autopsy or surgery to have occurred, are classified as the classical type. In this group there are 69 cases, or 51.8 per cent. The obscure type includes those patients in whom the onset was marked by abdominal pain which may have been excruciating (*forme fruste*) or dull in character, but who later did not develop signs and symptoms of a diffuse peritonitis. Such perforations were found by autopsy or surgery to be well localized abscesses which had not extended diffusely into the general abdominal cavity. In this group we placed 64 cases, or 48.2 per cent, of the entire series. It is significant from this fairly even incidence of the classical and obscure types that in many cases the diagnosis is difficult to make. Aird states that of the 79 cases which he collected from the literature, a correct pre-operative diagnosis was made only 5 times.

With this in mind, we carefully reviewed our records to see how often the diagnosis had been made correctly and what symptoms and findings were the most helpful in arriving at the

TABLE I.—PERFORATIONS OF GASTRIC CARCINOMA—133 CASES

	No. of cases	Per cent
Diagnosis confirmed by:		
Postmortem	66	49.6
Surgery	45	33.8
Surgery and postmortem	5	3.8
Clinical evidence	17	12.8
	133	100.0

TABLE II.—DISTRIBUTION ACCORDING TO SEX AND AGE

Sex	No. of cases	Per cent	Average age, years
Males	116	87.3	53.9
Females	17	12.7	49.2

TABLE III.—TYPES OF PERFORATION

Type	No. of cases	Per cent
Classical	69	51.8
Obscure	64	48.2
	133	100.0

diagnosis. In 42 cases, or 31.6 per cent, a diagnosis of perforated carcinoma of the stomach was made and proved to be correct by either surgery, autopsy, or both. In the great majority of those cases which were diagnosed accurately, the patient was in the hospital at the time the perforation occurred. Many had palpable masses and in some roentgen-ray studies were suggestive of malignant lesions. When the patient was first seen after the perforation had occurred and the abdomen was board-like with widespread tenderness, further examination revealed very little to differentiate this condition from a perforated peptic ulcer or perforation of some other hollow viscus. A history of rapid weight loss, vomiting, and constipation, occurring in a middle aged man who has suffered little, if any, from previous dyspepsia, weakness, and epigastric pain, is given considerable weight in diagnosing a malignant perforation. Of the 42 cases correctly diagnosed, 35 were perforations into the general peritoneal cavity. Only 7 times was the obscure type of perforation correctly diagnosed.

Fluoroscopic examination of the abdomen showed free air to be present above the diaphragm in 24 cases. Credit should be given to Vaughn and Singer (18, 19) for having pointed out and stressed the importance of this finding in perforations of hollow viscera. Had this method of examination been carried out routinely, the diagnosis, no doubt, would have been accurate in a far greater number of cases. It is strongly recommended that this method of examination be used more frequently.

TABLE IV.—VARIOUS FINDINGS INVOLVED IN THE SERIES

Symptoms and findings	No. of cases, present	Per cent	No. of cases, absent	Not stated
Hematemesis	59	44.3	69	5
Constipation	83	62.4	..	33
Diarrhea	12	9.0	88	33
Palpable mass	78	58.7	55	..
Weight loss	94	70.6	2	37
Tarry stools or occult blood	108	81.1	..	25
Free acidity	16	30.1	37	80
Positive blood Wassermann	8	6.0	109	16
Virchow's node	10	7.5	81	42

HEMATEMESIS

Fifty-nine patients, or 44.3 per cent, gave a history of hematemesis and 69 were without this symptom. With the exception of 3 cases, all the hemorrhages were of the limited recurrent variety. In 5 cases there was no reference made to hematemesis. Ransom and Coller state that in 46 cases, 50 per cent of the patients had hematemesis.

WEIGHT LOSS

Perforations in carcinoma of the stomach generally follow lesions of long standing and for this reason weight loss is a rather constant finding. Of the 133 cases, 94 were reported as having lost weight. Only 2 patients in the entire series gave a definite history of no weight loss. A mention of weight loss was not recorded in 37 of the cases. Very often when the perforation was of the classical variety the history of extreme weight loss was helpful in making the correct diagnosis. The greatest weight loss in the series was noted in a patient who had lost 80 pounds in the preceding 3 years and 6 months.

PALPABLE MASS

As stated before, with a classical perforation the abdominal muscles are rigid and little can be elicited by abdominal palpation. With this in mind we studied the records to ascertain just how often a mass in the epigastrium had been found. There were 78 patients, or 58.7 per cent, who were found to have had palpable masses. Many of the perforations occurred while the patient was in the hospital and the finding of the mass was recorded on the chart prior to symptoms of perforation. In 55, or 41.3 per cent, of the patients no mass was palpated.

STOOLS

A history of tarry stools or the symptom of occult blood was found in 108, or 81.1 per cent, of

TABLE V.—SITE OF CARCINOMA AS SHOWN BY AUTOPSY, SURGERY OR X-RAY

Site	No. of cases
Lesser curvature	45
Prepyloric	28
Cardiac	20
Greater curvature	11
Fundus	6
Anterior wall	4
Posterior wall	3
Posterior wall or pylorus	3
Pars media	3
Antrum	1
Entire stomach	1
Unknown	8
	133

TABLE VI.—AUTOPSY OR BIOPSY REPORT—TYPE OF PATHOLOGY PRESENT

Pathology present	No. of cases
Adenocarcinoma	27
Ulcerative carcinoma	20
Ulcerative adenocarcinoma	12
Medullary	5
Scirrhus	4
Ulcerative medullary	4
Medullary-adenocarcinoma	3
Anaplastic	3
Fungating adenocarcinoma	1
Ulcerative polypoid	1
Ulcerative scirrhus	1
Papillary medullary	1
	82

the cases. In 25 cases there was no mention made of tarry stools or of stool examinations for blood.

It has been stated that bleeding peptic ulcers rarely perforate. This obviously does not hold true in perforations occurring in carcinomatous ulcers, since 81.1 per cent of the perforations reported in this series of cases showed gross or occult blood in the stool.

Constipation was present in 83 cases, or 62.4 per cent. Diarrhea was listed in 12 cases, or 9.0 per cent, and 5 cases had alternating diarrhea and constipation. In 33 cases there was no reference made to any alteration in bowel habit.

ACIDITY

Free hydrochloric acid was found in only 16 of the 53 cases, or 30.1 per cent, in which gastric analyses were done.

VIRCHOW'S NODE

The presence of a palpable node in the left supraclavicular space was demonstrated in 10, or 7.5 per cent, of the cases.

SYPHILIS

It has been suggested that syphilis might favor perforation but we were unable to find that there was any correlation between perforating gastric cancers and syphilis. In both hospitals routine serological examinations are done on admission. In 109 cases of our series the blood was reported as negative. In 8 the reports were positive. In 16 no report was made.

SITE OF CARCINOMA

It will be noted from Table V that no region in the entire stomach is immune from malignancies that perforate. The sites of carcinoma listed were taken from operative, autopsy, and roentgen-ray reports and the terms used in the reports were not always definite. It will be noted, however, that the lesser curvature, prepyloric region, and cardiac end of the stomach were the most frequent sites of perforation. Of the 17 cases of perforation included in this series which were proved only by clinical evidence, 9 patients had undergone previous x-ray examinations which revealed typical malignant appearing lesions, and 8 had no roentgen-ray studies made.

Aird states that of the 79 cases which he collected from the literature, over 50 per cent of the patients were in bed at the time the perforation occurred. We studied our records in an endeavor to find out just where the patient was at the time of the perforation. We found that 71, or 53.5 per cent, were either in bed in the hospital or in bed at home. Sixty-two, or 46.5 per cent, were not confined to their homes but were working or walking around at the time of perforation. Of those working, many were indulging in strenuous physical exertion at the time. One unfortunate victim was cheering at a baseball game when seized with a stabbing pain in the abdomen. Surgery revealed a perforated gastric cancer to be the cause of his pain.

ULCER HISTORY

We will not enter into the controversy (4, 5, 10, 22) of cancerous ulcers and ulcerous cancers of the stomach. Suffice it to say that of the 133 cases, 24, or 18 per cent, had typical peptic ulcer symptoms for many years prior to perforation.

TYPES OF CARCINOMA WHICH PERFORATE

Eighty-two patients, or 61.7 per cent, were studied as to the type of carcinoma present. Seventy-one were studied at autopsy and in 11 patients the diagnoses were made from tissue removed at the time of operation. Adenocarcinomas and those listed as ulcerative carcinomas most frequently perforate. The entire group is included in Table VI.

TABLE VII.—PATHOLOGY FOUND SECONDARY TO PERFORATION

Pathology	No. of cases
General peritoneal cavity (diffuse peritonitis)	53
Perigastric abscess	34
Gastrocolic fistula	15
Subdiaphragmatic abscess	12
Perforation with multiple liver abscesses	5
Perforation into pancreas	4
Perforation into anterior abdominal wall	2
Pylorojejuno-gastric fistula	2
Gastrocholedochal fistula	2
Perforation into and around spleen	1
Gastrojejunal fistula	1
Perforation into left lung	1
Perforation into right lung	1
	133

TABLE VIII.—TYPES OF SURGICAL PROCEDURES

Procedures	No. of cases
Simple closure, with or without drainage	23
Posterior gastro-enterostomy	7
Anterior gastro-enterostomy	7
Gastro-enterostomy (type not given)	7
Resection of stomach (Pólya type)	7
Drainage of peritoneal cavity only	5
Exploration of peritoneal cavity without drainage	4
Gastro-enterostomy and entero-enterostomy	1
Closure of perforation and appendectomy	1
Closure and gastrostomy	1
Patients not operated upon	70
	133

PATHOLOGY SECONDARY TO PERFORATION

Perforations into the general peritoneal cavity occurred in 36 patients who came to surgery or autopsy. These cases, together with the 17 cases which are listed as proved by clinical evidence in this series, would bring the total to 53 cases, or 39.8 per cent.

Localized perigastric abscesses were found in 34 patients and gastrocolic fistulas in 15. Twelve perforations resulted in subdiaphragmatic abscesses. Other less frequent pathological findings incident to carcinomatous perforations are included in Table VII. It will be noted that some of these lesions are capable of extending and forming abscesses which may perforate into adjacent viscera or into the chest.

Regional nodes (20) were found to be present in 76 patients studied at autopsy or surgery. This finding suggests that perforations usually occur late in the disease. Many of the nodes, however, were not studied microscopically and may have been inflammatory in character.

SURGICAL PROCEDURES

In reviewing the 133 histories of patients with perforated gastric carcinoma, it was interesting to note that in only 63 of the patients was any type of surgery attempted. Many were moribund when first seen and could not be given the benefit of surgery. Others were operated upon under the diagnosis of an "acute abdomen" while still others were thought to be suffering from perforated peptic ulcers. As will be noted from Table VIII, the surgeons were confronted with various technical difficulties which were dealt with by several different methods. In 23 cases simple closure of the perforation with or without drainage was done. Posterior gastro-enterostomy was done in 7 cases. An anterior gastro-enterostomy was done in 7 cases. The operation record was indefinite in 7 other cases, but one could conclude from the record that either an anterior or a posterior gastro-enterostomy had been done. From this it will be seen that 21 cases were submitted to gastro-enterostomy to relieve the obstruction after the perforation had been closed. Gastric resection of the Pólya type was done in 7 cases.

SURGICAL RESULTS

Of the 63 patients operated upon, 37 died within the first 10 days giving an immediate operative mortality rate of 58.7 per cent. Thirteen patients lived to survive their operations but died within the next 2 months. Of the entire group of 63 patients only 13 lived to be discharged from the hospital as improved. No follow-up was reported on the survivors so no "permanent" recoveries are recorded. It was interesting to note that of the procedures done on the 13 "survivors," 5 had resections of the Pólya type, 4 had gastro-enterostomies, 3 had simple closures, and 1 had a gastrostomy. The necropsy reports on many of the simple closures showed that there had been leakage at the suture line. The friability of carcinoma and the attendant difficulties in suturing perforations of these lesions are further emphasized when we realize that only 3 of the 23 patients who had simple closures lived to be discharged from the hospital. On the whole, the poor general nutritional state and the age of the patient were also pertinent factors governing the mortality.

From the discouraging end-results as disclosed in this survey, we are prompted to hypothesize on procedures which might give better results. We believe that when the patient has suffered a perforation of a gastric carcinoma 2 factors are to be considered, namely, the closure of the perforation and the removal of the malignancy. Generally, when first seen, the condition of the patient is so desperate that extensive surgery is contra-

indicated. All effort should be directed at closure of the perforation and relief from any existing obstruction. Removal of the malignancy when possible should be reserved for the time when the patient is better able to withstand a more formidable procedure (13).

A primary resection is the ideal method of treatment (15). Closure of the perforation with or without a gastro-enterostomy followed at a later date by a resection is probably the procedure of choice in most cases.

It is our belief that a biopsy should be done of all perforations of the stomach. Occasionally patients with gastric perforations, which are closed and thought to be on a benign ulcer basis, return after several months with an inoperable carcinoma. A routine biopsy would obviate this situation and give the patient the benefit of radical surgery at an earlier date.

SUMMARY AND CONCLUSION

1. Of 3,289 cases of gastric carcinoma admitted to Cook County Hospital and Wesley Memorial Hospital during the period 1925–1937, there were 133 perforations (4.04 per cent).

2. The group of perforations is divided clinically into the "classical" and "obscure" types. The classical type includes those cases which clinically appeared to be perforations into the general peritoneal cavity. The obscure type includes those cases in which there was localization of an abscess or a sealing off of the perforation. Both types are quite evenly represented in the series of cases.

3. The condition was correctly diagnosed in 31.6 per cent of the cases. Free air in the peritoneal cavity as shown by fluoroscopic examination was found to be a valuable diagnostic procedure.

4. A study of the incidence of the various symptoms and findings is presented. It is stressed that after perforation has occurred, examination of the abdomen is quite difficult and that a careful history must be relied upon in making the diagnosis.

5. As shown by our series of cases, cancer of the stomach may perforate irrespective of the location of the lesion. However, the lesser curvature, prepyloric region, and cardiac end are the most common sites.

6. Of 71 cases submitted to pathological examination, adenocarcinoma, ulcerative adenocarcinoma, and ulcerative carcinoma accounted for 50 perforations.

7. In 53 cases, including 17 which were not proved to be perforations but which had quite typical clinical findings, the perforations occurred into the general peritoneal cavity. Perigastric abscesses, gastrocolic fistulas, and subdiaphragmatic abscesses were also common sequelas of obscure perforations.

8. Various surgical difficulties were found in the 63 patients operated on, and various types of operations were done. In 70 patients no surgery was attempted, either because a diagnosis could not be made or the condition of the patient did not warrant surgical intervention. The immediate operative mortality rate was 58.7 per cent. Only 13 patients left the hospital as improved.

9. The surgical treatment in perforation of carcinoma of the stomach should be to aim at radical removal of the carcinoma. Simple closure of the perforation with or without a gastro-enterostomy to relieve any obstruction, is usually the only procedure attempted immediately following the perforation. More formidable procedures such as partial resection of the stomach must often be reserved for a later date when the patient is in better condition to stand extensive surgery.

10. It is our opinion that if a biopsy were done of all perforations thought to be due to benign peptic ulcers, many would be found to be malignant. If this routine were carried out many patients might have the benefit of early resection.

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EDITORIALS

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SURGERY AND RADIOTHERAPY IN THE TREATMENT OF CANCER

DURING the past two or three decades fundamental change in methods has been the order of the day throughout all branches of medicine. The internist has experienced tremendous alteration in his management of diabetes, pernicious anemia, the nephritides, cardiovascular disease and a host of other affections that are combatable now with new, or greatly improved, weapons. Likewise, the surgeon has accepted the introduction of many innovations, some in the technique of surgery, others in pre-operative and postoperative treatment, still others in the fundamental indications for surgical treatment.

While some of the changes seem revolutionary enough today, nevertheless they do not approach in scope those necessitated by the discovery of bacteria and the introduction of antisepsis and asepsis. Only sixty odd years ago, within the professional recollection of some surgeons still alive, Lister's principles elicited not only disbelief but active resistance on the part of many of the medical profession. In the light of our present knowledge it is hard to realize that the antagonism of thinking, intelligent men could have gone to such extremes of intolerance. Although the surgeon is probably more tolerant of change today, he still tends to eye with at least suspicion anything that represents very much of a departure from the established habit. This is especially true when changing trends seem to threaten the removal of certain diseases in part or in whole from the previously accepted field of operative surgery.

Probably in no field of surgery is this so well illustrated as in the treatment of malignancy. In 1913, articles in SURGERY, GYNECOLOGY AND OBSTETRICS from the clinics of distinguished surgeons voiced the general feeling of the time when they stated that the greatest hope in treating carcinoma of the cervix uteri lay in wide excision of the primary growth. In 1938, just twenty-five years later, the bulk of evidence indicates without doubt that radiotherapy, with radium and the roentgen-ray in combination, gives far better results than radical surgery, now or at any time in the past. Some surgeons, however, still persistently adhere to the use of radical operations of the Wertheim type in at least a part of the patients whom they are treating who are suffering with carcinoma of the cervix. They give ground grudgingly.

Twenty-five years ago carcinoma of the breast was treated almost exclusively by surgery. Today radical surgery is still the method

of general choice but evidence indicating the value of radiotherapy is accumulating so rapidly and surely that in some form it is commonly employed as a supplementary procedure. Some surgeons are so dissatisfied with the effectiveness of radical mastectomy and so impressed by the evidence indicating the benefits of radiation therapy that they are treating certain groups of patients with locally administered radiotherapy alone. Others, in search of still more effective therapy are investigating the supplementary treatment of mammary cancer, especially in younger women, through sterilization by x-ray irradiation of the ovaries. This form of therapy may foreshadow the accumulation of more evidence that carcinoma is a local manifestation of a systemic abnormality and, hence, may be solved by some type of systemic therapy rather than by local therapy.

Carcinoma in many other parts of the body might be mentioned to illustrate still further the changing trends in surgical and radiation therapy. The common factor in each instance, however, is the improvement in the character of available radiant energy and the betterment in the methods of its application. Higher voltage x-ray machines, better methods of filtration, more general availability of radium element and emanation and many other technical advances, as well as the training of more experienced radiotherapists, will give a real impetus to radiotherapy as a therapeutic agent in the next few years. The recently developed cyclotron, which makes it possible to imbue almost any substance with radiant energy, opens a field of unlimited possibilities. A great number of animal experimentations and clinical investigations, of course, must be carried out before its usefulness can be definitely determined, but if it is established it may well revolutionize the treatment of malignant tumors. With so much development going on in the field of radiotherapy, the surgeon must be prepared to receive sympathetically and in the spirit of constructive, rather than destructive, criticism the experimental and clinical evidence that will be presented. In some instances the data will no doubt justify and amplify the now accepted surgical principles; in others the facts will, equally without doubt, cause the abandonment and replacement of some principles that today seem so fundamental and inviolate. There is, of course, always the possibility of the too uncritical acceptance of methods that are presented without proper and adequate fundamental study and evaluation. This extreme may be as unfortunate as the other. The pendulum swings periodically. It will require experience and discrimination for each surgeon to decide the amplitude of his swing and to avoid going to extremes in either direction.

The fundamental evaluation of, and comparison between, surgery and radiotherapy can be carried out most successfully only through close association between the surgeon, the x-ray therapist, the radium therapist, the surgical pathologist, the postmortem pathologist, and the experimental physiologist. This association perhaps reaches its ideal in the "tumor clinic" type of organization. In such a group, the patient with a tumor and the patient that has been treated for a tumor are observed and data recorded so that the results in the individual and in series of individuals may be studied and compared. Each physician contributes of his own specialized knowledge of the disease and benefits through the correlation of various viewpoints. Through this kind of concerted effort will come the basis for the establishment of improved methods that will be a credit to both the surgeon and the radiotherapist in the safest and best management of the patient with cancer.

CHARLES BRUCE MORTON.

LIFE OR DEATH OF THE FETUS: A NEW GRAPHIC TEST IN PREGNANCY

AMONG the many signs of pregnancy, the few positive signs are those which reveal the presence of the fetus. Only two of them tell whether the fetus is alive. One consists in hearing and recording the fetal heart beat by means of the stethoscope; the other, in observing active or passive movements of the fetus. Both signs depend on subjective information and may be mistaken. It occurs not infrequently in the course of pregnancy, especially in the course of labor, that doubt exists as to whether the fetus is still alive. Important surgical decisions may depend on the correct and immediate diagnosis. An objective, unprejudiced method, independent of suppositions, is needed to fill this gap in obstetrical diagnosis.

After electrocardiography had become an indispensable method in medicine, repeated attempts were made to obtain the fetal electrocardiogram in the course of pregnancy. They failed for various reasons. In the first place nobody knew how a fetal electrocardiogram superimposed on that of the mother would look. In the second place, there was no proper technique developed and the sensitivity of the apparatus did not seem sufficient.

To overcome the difficulties, investigators started work on domestic animals,[1] the fetuses of which are larger than those of human beings. After the action of the fetal heart had been demonstrated unequivocally in the electrocardiograms of pregnant mares, the next step was to apply to pregnant women the technique and the knowledge gained. Deviations regularly occurring in the electrocardiogram of the human mother, corresponding to the rhythm of the fetal heart beat, were obtained.[2, 3]

After identification of the fetal cardiac impulses in the electrocardiogram of a pregnant woman had become possible, it remained to improve and simplify the technique so that increase in the percentage of positive results would render the method applicable for routine purposes. Complicated electrotechnical experiments, and changes in the apparatus which were necessary during the experimental stage, had to be eliminated if the test was to come into daily use. The investigators, therefore, observed the following principles:[4] (1) Any modification of the electrocardiographic apparatus which was generally in use was avoided. (2) Unusual leads, such as placing of electrodes in the rectum or vagina, or on the abdomen, were not employed. Application of electrodes to extremities is familiar to everybody and, therefore, preferable to fetal electrocardiography. (3) In spite of these limitations, it was necessary to increase the sensitivity of the test; in other words, to increase the amplitude of the various waves. At the same time, it was necessary to decrease the tremor of the tracings, that is, to eliminate, as far as possible, muscular fibrillation and interference from the outside, especially that attributable to electric current.

The main points of the final technique which was developed on the basis of these three principles in short are: (1) The patient was placed flat on her back on a couch. (2) The skin and the electrodes were moistened with saturated saline solution. (3) The electrodes were placed on the upper parts of the arms and left thigh. (4) The electrodes were fastened with bandages which had been soaked

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[3]Strassmann, Erwin O. The fetal electrocardiogram late in pregnancy. Proc. Staff Meet. Mayo Clin., 1936, 11: 778–782.

[4]Strassmann, Erwin O., and Mussey, Robert D. Technic and results of routine fetal electrocardiography during pregnancy. Am. J. Obst. & Gynec. (In press.)

in saturated saline solution. (5) The patient rested 10 to 15 minutes before the electrocardiogram was taken. (6) Tracings were taken with the usual leads, I, II, and III. (7) The electrode was changed from left thigh to right thigh. (8) Tracings then were repeated with leads II and III (right arm—right thigh; left arm—right thigh, respectively). (9) Two feet (61 cm.) of film were exposed for each tracing. (10) Disturbances from other electric apparatus were guarded against. The five leads thus applied covered the main directions which the axis of the fetal heart might have in the body of the mother, projected on a two dimensional field.

During the last two months of pregnancy, with the technique here described, about 87 per cent of fetal electrocardiograms were positive. That is, a negative result did not mean that the fetus was dead, but a positive result was definite proof that the fetus was alive.

The closer the approach to term, the higher was the percentage of positive fetal electrocardiograms, corresponding to the increasing size and increasing strength of the electric impulse of the fetal heart. In the last three weeks the percentage of positive fetal electrocardiograms ran up to 94 if the fetus was in vertex presentation. Among these cases the percentage of positives was higher than among breech presentations owing to the fact that in the presence of breech presentations the fetal deviations were deflected above the zero line and therefore were recognized with somewhat more difficulty (because of the confusing positive maternal waves) than were the fetal waves in the presence of vertex presentation, which appeared deflected below the zero line. On the other hand, the diagnosis of breech or vertex presentation could be made without examining the patient, on account of the direction of the waves. A fetal electrocardiogram was regarded as positive only if it was possible to follow the fetal waves all through the tracings and to give the exact fetal heart rate. The fetal waves occurred regularly, in a rhythm independent of that of the mother. The size of, and the distance between, the fetal deviations were constant. The fetal waves appeared first in that lead which was almost parallel to the axis of the fetal heart. The larger the fetus, that is, the later in the course of pregnancy, the larger was the number of leads which became positive and this made the diagnosis much easier. It was found justifiable to expect that 75 per cent of all electrocardiograms taken in the last two months of pregnancy would be positive in at least two leads and about 30 per cent in four leads. There was no use in taking electrocardiograms before the last third of pregnancy, since the fetal heart action was too weak to exert any visible influence on the tracings obtained by the technique adopted by the investigators.

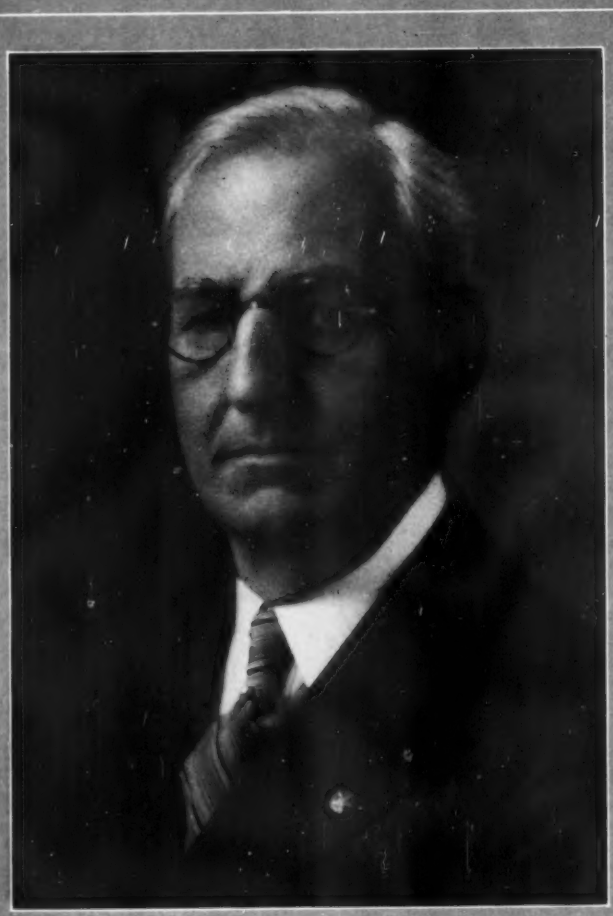
Fetal electrocardiography is not to be considered as another pregnancy test but is meant to determine, during the last period of pregnancy, especially during labor, whether the fetus is alive. For instance, in some cases in which patients are rather fat, the fetal heart cannot be heard, even in the last days of pregnancy. A positive fetal electrocardiogram in such cases would give definite proof that the fetus was alive.

The main practical field for fetal electrocardiography, apparently, will be in the course of labor, when active movements of the fetus usually stop and listening for the fetal heart beats by means of the stethoscope does not always give convincing results. Furthermore, to have electrocardiographic tracings might occasionally be of medicolegal value. To be able to produce tracings showing that a fetus was alive at a given time might be useful under certain circumstances.

Besides being of practical importance, it would seem that fetal electrocardiography opens a wide field for research. The relationship between the cardiac action of the mother and that of the fetus under normal and under pathological conditions can be studied on the basis of records of documental value. The influence of type and duration of labor; of various presentations and complications; of all kinds of drugs, including narcotics and anesthetics; of disturbances in fetal circulation (loops and knots in the umbilical cord) and so forth, on the fetal heart action are problems which might be investigated. On the basis of these studies it might be possible to make a more exact prognosis concerning the life of the fetus under various conditions. Still there is a certain percentage of cases in which babies are stillborn but in which stillbirths had not been expected when labor was in progress. Fetal electrocardiography might become of great assistance in decreasing the number of those undesired surprises in the delivery room.

Concerning twins, fetal electrocardiograms are interesting. Without examining the patient otherwise, it has been possible to make a diagnosis and to state whether one fetus is in vertex presentation, the other in breech presentation, and so on, from the direction of the fetal waves alone.

Fetal electrocardiography requires some experience in taking and reading the tracings; this can be acquired by any obstetrician. It is still a new method which can be improved. However, it has possibilities of being of value for practical, for medicolegal, and for scientific purposes. ERWIN O. STRASSMANN.



JOHN L. PORTER

1864-1938

MEMOIRS

JOHN LINCOLN PORTER

JOHN LINCOLN PORTER, the son of Samuel and Harriet Emerson Porter, was born in Alstead, New Hampshire, July 2, 1864. The family traced their origin to John Porter who left England to settle in Salem, Massachusetts, in 1634. In his early childhood John Porter moved with his family to the little New England community of Walpole, New Hampshire, where his father was a school teacher, storekeeper, and lay preacher. He received his early education at Walpole Academy from which he was graduated at the age of seventeen.

After graduation from the Academy, John Porter decided to go to Chicago, where his brother Frank, some nine years older, was in the employ of Marshall Field and Company. Perhaps Horace Greeley's quotation, "Go West, young man, and grow up with the country," stirred his imagination. This was the time, too, when Chicago was rebuilding its fortunes from the disastrous fire of 1871. In any event, he joined the throng and began his career in the shipping room of Marshall Field and Company and at the age of twenty-two was sent on the road as a salesman; for three years he continued to sell merchandise over the western prairies.

There was a strong attachment between John and his brother Frank, who being older, virtually took a father's place. This close relationship endured throughout their lives. One day when out walking in Chicago, Frank noticed his younger brother's interest in drug stores where he would often loiter at the windows. He offered a suggestion and a loan of money to buy one; the result was the purchase of a store near 22nd Street and Prairie Avenue.

John Porter immediately launched himself in a new career by taking a course in pharmacy at Northwestern University, meanwhile employing a pharmacist to operate the store. Apparently the new interest stimulated him to go further, for one year after he completed his training as a pharmacist he returned to Northwestern to study medicine. For a while he operated the store and at the same time carried on his studies, but as he advanced the store was sold. In 1893, the year of the World's Fair, he was employed in the horticultural building during the summer and the following year was graduated from Northwestern University Medical School.

During the next two years Dr. Porter served as an interne in St. Luke's Hospital under McArthur, Dudley, Ridlon, and others, well known in early Chicago medical history. He always looked back on this period of training as an invaluable experience, for interneships in those days were rare. At least it

became a definite turning point in his career and about this time events occurred which directed his course toward bone surgery. One of these was the impairment in hearing which was first noticed in medical school and which he traced to a serious illness with scarlet fever at the age of eight.

Many reminiscences remain from this early period such as the time he haggled with the hospital superintendent for ten dollars to buy some of the then little known anti-tetanic serum for a hospital patient suffering from lock-jaw. It was finally obtained and the patient recovered.

After leaving St. Luke's Hospital he spent his first summer in active practice, taking over Dr. Julius Hoag's obstetrical work while the latter spent the time abroad; subsequently he did the same for Dr. William Allen Pusey. He delighted to recall these short periods of "specialization"; however, this was soon over and he directed his serious attention to orthopedic surgery.

In 1899, Dr. Porter was married to Ethel Quigg, the only daughter of Col. David Quigg, a Chicago attorney and former officer in the Union Army. From this marriage two sons were born.

Dr. John Ridlon, who had received his training in New York with Sayre and Taylor, was then the pioneer orthopedic surgeon in Chicago and Dr. Porter formed a close association with him. He rapidly devoted himself, with the boundless energy which he possessed, to this new work. The crippled child came to know him as a friend indeed, and the Home for Destitute Crippled Children was his sanctuary. In 1900, the University of Illinois recognized his worth by appointing him Professor of Orthopedic Surgery, a position he held until 1917, when he was called to Northwestern to occupy a similar chair.

Perhaps one of the most outstanding periods in his long, active life was this teaching era. At least he is best remembered by thousands of students who still tell of his rare skill. He possessed an unusual ability to talk clearly without notes and his dry clinics were exceptional. Students would carry away fundamentals that they never forgot. Such natural teachers are rare and his was a real gift. Besides this general teaching experience he was always surrounded by a smaller group of men who received graduate instruction from him. Many orthopedic surgeons of today can trace their early training to his genuine interest in their personal careers. Although from time to time he contributed papers to the surgical journals, this was not an important part of his medical life. Far more outstanding than his gift for teaching was his devotion to the organization of orthopedic surgery, the training of surgeons, and the development of higher standards in that particular branch of general surgery.

In 1901, he was elected to membership in the American Orthopædic Association. There began a long, active association in which he served for thirty-five years as the society's treasurer, even during the year he was president, a necessity forced on him by the death of the appointed treasurer. During this time he was

instrumental through wise counsel and constant interest in directing the course of orthopedic training, teaching, and organization. Though for many years he would annually resign his office, members of the association would not permit it and even in 1938, when, for reasons of health, he seriously felt he must give up, he was again re-elected. No more fitting tribute to his sincere interest, fidelity, and devotion to orthopedic surgery could be found.

Dr. Porter was deeply interested in the development of many orthopedic groups: his was the job of organizing the orthopedic section of the American Medical Association and in October, 1937, a Silver Jubilee of the Clinical Orthopædic Society was dedicated to him as the founder. The organization was first known as the Central States Orthopædic Club and probably no meeting afforded Dr. Porter such a touching personal tribute as this one.

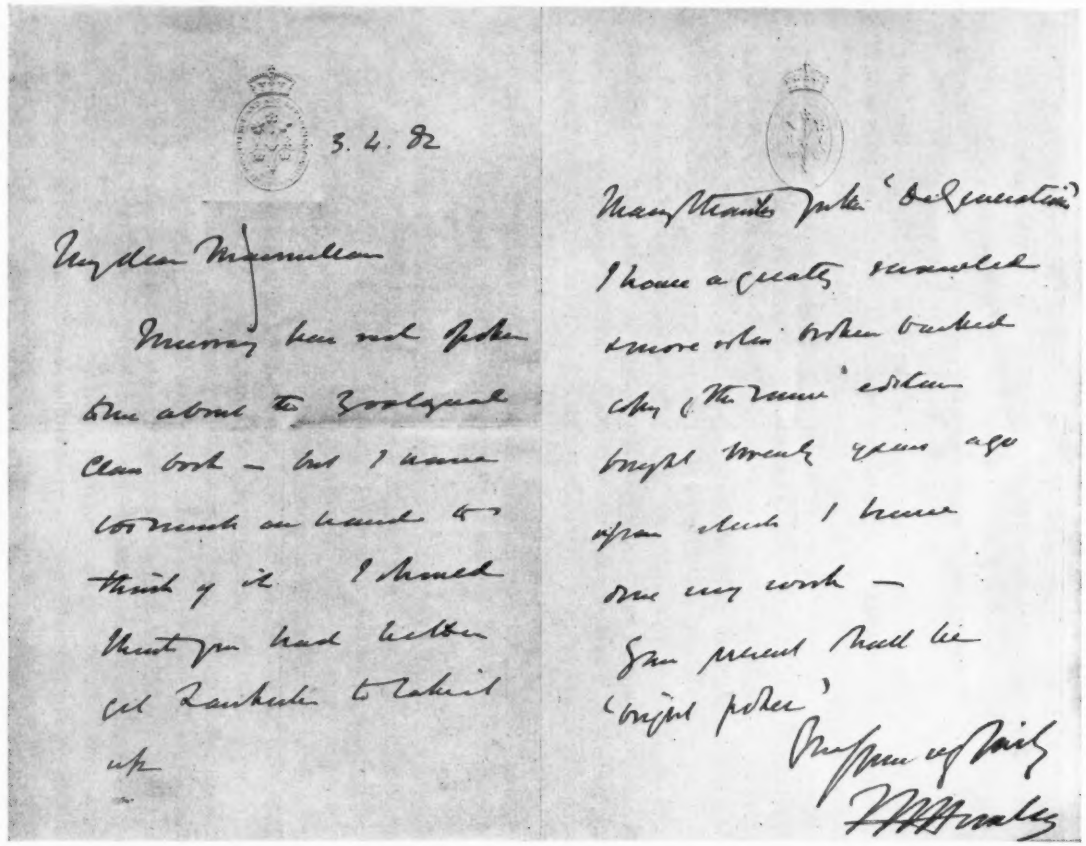
His third important contribution to medicine was his abiding interest in the development of the medical journals. He was elected a Fellow of the American College of Surgeons in 1913, and in 1915, was made a member of the editorial staff of the journal, SURGERY, GYNECOLOGY AND OBSTETRICS, a position he held for eighteen years. From the time of the organization of the INTERNATIONAL ABSTRACT OF SURGERY he was editor of the orthopedic section until very recent years; even closer was his association with the *Journal of Bone and Joint Surgery*, which he watched from its infancy. Through his office as treasurer of the American Orthopædic Association he was able to take a long and active part in developing this journal—the official journal of the association. No one except Dr. Brackett, its able editor, could tell the unwritten story of Dr. Porter's part in the trials and tribulations of its growth.

During the World War Dr. Porter was appointed a member of the advisory board of orthopedics, and later, as a Major in the Medical Corps, he was in charge of the orthopedic service at General Hospital No. 36, Fort Des Moines, Iowa.

For many years he was on the attending staff of St. Luke's Hospital, Cook County Hospital, and the Evanston Hospital.

Few men have devoted themselves more unselfishly to the attainment of higher standards in their chosen specialty than he did. This was to be his great contribution to medicine and he managed to do it in a way that commanded the admiration and respect of his co-workers. No orthopedic meeting was complete without his genial presence and the group of friends which constantly surrounded him bespoke a personal tribute which delighted his very soul. His death at seventy-four came sharply and decisively on August 11, 1938, in a manner, singularly characteristic of his whole life and as he would desire it—the end of a long, useful career.

ROBERT C. LONERGAN.



3. 4. 82

My dear Macmillan

Murray has not spoken
to me about the Zoological
Class book — but I wrote
to remind him of it & to
think of it. I should
like you to have letters
of Rankester to fabricate
up

Many thanks for the "Dedication"
I have a greatly extended
experience of books dedicated
to "The Queen" & other
mighty monarchs & you
upon the whole I believe
are very worst —
Your present shall be
"Right Royal"

Yours very faithfully
T. H. Huxley

Facsimile of autographed letter from *Dr. Thomas Henry Huxley* to a book publisher. Professor Huxley was very jealous of his autograph. In one of his letters, sold by auction, he wrote: "I look upon autograph hunters as a progeny of Cain, and treat their letters accordingly; heaven forgive you if you are only an unusually ingenious specimen of the same race."

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

FOR a great many years Sauerbruch's *Die Chirurgie der Brustorgane* has been the principal deposit of the lore of thoracic surgery. Whoever was familiar with the language and had access to the volumes could consult them with the assurance of a profitable return. The normal obsolescence to which all textbooks are subject was compensated for by good historical surveys and extensive reference to the accumulated literature. The price of the book was greater than many felt they could afford and the barrier of language stood in the way of many others. For these reasons the idea of an English translation has occurred to many.

Thoracic Surgery[1] by Sauerbruch and O'Shaughnessy is a condensation and modernization of Sauerbruch's original work. The condensation has sacrificed considerable that made the older work permanently valuable and the modernization has not been as complete as one might wish. This is particularly evident in the section on the collapse therapy of pulmonary tuberculosis; the discussion of indications is hurried and dogmatic and that of technique not abreast with current practice in other clinics. A great number of the improvements in thoracoplasty which have been so successful in lowering the mortality and increasing the percentage of clinical cures are not mentioned. This is true of the current practice of removing the full lengths of the upper ribs; it is true of Semb's apicolysis and of the practice of removing or sectioning the costal cartilages. In these important respects the book is not adequate and should not be trusted as a guide to present practice.

There is scarcely anyone who has so impressed himself upon a field of surgery as has Ferdinand Sauerbruch. His name is now, and for many years to come will be, almost daily upon the tongues of all who do thoracic surgery. From 1907 and 1908, when, as Fredreich's assistant, he helped to carry out Brauer's important ideas on collapse of the lung, he has interested himself chiefly in surgery of the chest. Both as a contributor and a popularizer he has led and dominated the field. While most of the important discoveries have been made by other men they were able to do so only because Sauerbruch had opened up the field.

JEROME R. HEAD.

RECENTLY Edward C. Brenner has written quite an extensive volume,[2] covering 843 pages and designed to serve as a textbook for those interested in the practical side of the field of surgery in children. It accomplishes its objective very well, I think, but it does omit any discussions of fractures, dislocations, and other orthopedic conditions. Special emphasis has been placed on pathology, diagnosis, and treatment of every condition discussed, but any reference to the literature, bibliographies, or theoretical discussions have been entirely omitted purposefully by the author. Certain chapters, such as that on blood transfusion, congenital cleft lip and palate, surgery of the chest, urologic conditions, and neurological surgery have been written as special articles by various prominent men. Otherwise the entire text is a product of the author himself. It is very well illustrated by many excellent photographs, clear x-ray prints, and drawings.

After very carefully reviewing this book I cannot help but feel that it is a valuable addition to the list of books covering this field of practice.

EDWIN M. MILLER.

DR. CUSHING'S most recent monograph[3] on the meningiomas cannot be considered by the ordinary rules of book reviewing. Stamped indelibly with his style, it is more than a mere record of 300 intracranial tumors of a specific type. It tells vividly of the disappointments, the discouraging moments, and the brilliant success in a battle directed by one individual against a group of intracranial tumors the treacherous nature of which ensnares the unwary and often the wise and experienced surgeon. It is colored brightly by the unbroken succession of marks of influence which Harvey Cushing has placed upon the art and science of neurological surgery. It is filled with the unwavering confidence and devotion which his patients throughout the years have shown to his surgical skill and judgment—and to these companions in battle he pays glowing tribute.

Dr. Cushing has often said that the conscientious surgeon should look upon the results of his work much like his golf score—as something against which he must be constantly shooting in an effort to reach par; that the self-discipline of such an attitude rigidly enforced was good for the surgeon's soul. Here then is a record of that game, if you please, played against the meningiomas. Beginning at Johns Hopkins Hospital at a time when neurological surgery was non-existent as a surgical specialty, starting his own surgical career, and without a great deal of encouragement from his seniors for his efforts in a field of surgery which they felt was hopeless and

[1] THORACIC SURGERY. A revised and abridged edition of Sauerbruch's DIE CHIRURGIE DER BRUSTORGANE. By Ferdinand Sauerbruch and Laurence O'Shaughnessy, F.R.C.S. Baltimore: William Wood & Co., 1937.

[2] PEDIATRIC SURGERY. By Edward C. Brenner, A.B., M.D., F.A.C.S. Philadelphia: Lea & Febiger, 1938.

[3] MENINGIOMAS; THEIR CLASSIFICATION, REGIONAL BEHAVIOUR, LIFE HISTORY AND SURGICAL END RESULTS. By Harvey Cushing, M.D. With the collaboration of Louise Eisenhardt, M.D. Springfield, Ill. & Baltimore, Md.: Charles C. Thomas, 1938.

limited, one may read of the struggle against what must have seemed at times to be hopeless odds. The score he has entered is one against which all other neurological surgeons must play.

Meticulously kept records on every patient, the rigid requirement of verification of tumors by microscopic section, operative notes written at the moment and often illustrated to capture a point difficult to describe and, I suspect, many hours of self-communion to discover how he might have done better, all have combined in these pages to reveal the master surgeon. During his career he has seen the development of more exact and earlier diagnosis in intracranial lesions; the improvement of surgical technique which has made operations upon the brain safe procedures; the lessening of hemorrhage by operations performed under local instead of general anesthesia; the introduction of electrosurgical methods; the classification of tumors into groups and the correlation of their clinical behavior with their microscopic appearance; and the training of young surgeons in the art of neurology and the other allied fields necessary for successful accomplishment. In all of these endeavors he has shown the way to those who attempt to follow in his footsteps. One wonders which he considers the most important contribution, but I suspect it was his conception and insistence upon the carefully planned technique of those early operations which successfully laid the ghost of infection, cerebral fungus, and ugly mutilating scars. This was *sine qua non*. It is possible, of course, that many of these contributions may undergo modification in the future and to whom the original credit belongs may be forgotten, but the stimulus and encouragement he has given to the succession of youngsters in this country and abroad who have set their sails under his guidance will always remain his monument.

Written in a charming style, the material and statistics arranged in an interesting manner by Dr. Eisenhardt, the book does not need to be read by a neurological surgeon to follow the story with profit to his surgical soul. L. D.

A BOOK that covers well every phase of the work expressed in the subject treated is the work by Cheney on *Diagnosis and Treatment of Diseases of the Stomach and Intestines*.[1]

The text is well planned. Dr. Cheney has selected the best methods for diagnosing and treating diseases of the stomach and intestines and has presented them briefly, but with such definite clearness and enough detail that it should be of much practical value to every physician and surgeon.

The book is divided into two parts. Part I deals with diseases of the stomach and Part II with diseases of the intestines. Preceding each part is a brief discussion on the best methods available for investigation of patients with "stomach trouble" and the intestinal diseases.

Each chapter is a complete discussion of the diagnosis and treatment of a certain group of diseases. The cause of the disease, the clinical history of the disease, the physical examination, and the various methods necessary for the diagnosis and treatment of the disease are presented in a most comprehensive manner.

The author has not forgotten the physician who does not have the assistance of the hospital or of a technician, and has simplified the laboratory methods so that many of them can be carried out by the physician himself.

I strongly recommend this book to every physician and surgeon, and especially to those who are young in the profession. C. J. BARBORKA.

IN the preface of the book on *Diseases of the Nervous System of Infancy, Childhood, and Adolescence*,[2] Ford states that he has attempted to include all the (neurologic) conditions which occur in childhood, and in this difficult task he has succeeded well. However, the number of topics treated (about 400 are listed in the table of contents) has necessitated such economy of expression as to interfere at times with adequate presentation; indeed, some subjects are given no more than thumbnail description. The pediatrician may find its descriptions too sketchy; for the neurologist it cannot displace the larger texts, monographs, and systems to which he is accustomed; for the undergraduate it is insufficiently elementary. However, the usefulness of the work is enhanced by the numerous small bibliographies, which for the more interested reader, may serve as an entrée to the literature. HARRY A. PASKIND.

THE comprehensive work on *Pediatric Urology*[3] is unquestionably the best of its kind. It is enhanced by a voluminous bibliography and excellent index. It is profusely illustrated and reveals a wealth of clinical material. Included in the second volume is a section on Bright's disease in infancy and childhood by John D. Lyttle. It is a valuable addition by one who has devoted many years to the problem of nephritis in children. This feature, the author justly believes, should be included in all urologic texts. The urologist should be familiar with the medical as well as the surgical diseases of the kidney.

The consideration of anomalies of the genitourinary tract is well over 200 pages, which emphasizes their importance, inasmuch as most urologic surgery in the young is occasioned by an anomalous development complicating infection.

Indications and contra-indications are clearly expounded.

[1] THE DIAGNOSIS AND TREATMENT OF DISEASES OF THE STOMACH AND INTESTINES. By William Fitch Cheney, B.L., M.D. Henry A. Christian, M.D., Sc.D., LL.D., Editor of series. (Reprinted from Oxford Monographs on Diagnosis and Treatment.) New York: Oxford University Press, 1936.

[2] DISEASES OF THE NERVOUS SYSTEM OF INFANCY, CHILDHOOD, AND ADOLESCENCE. By Frank R. Ford, M.D. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1937.

[3] PEDIATRIC UROLOGY. By Meredith F. Campbell, M.S., M.D., F.A.C.S. With a Section on Bright's Disease in Infancy and Childhood by John D. Lyttle, A.B., M.D. Vols. 1 and 2. New York: The Macmillan Co., 1937.

The volumes are of comfortable size and the subject matter is simply divided.

Dr. Campbell's invaluable contribution to urology most certainly shows its 10 years of active preparation. It is the only work of its kind in any language. It belongs in every library. L. L. VESEEN.

EVERY medical student should find of value the book on *The Management of Fractures, Dislocations and Sprains*[1] because, whatever his fracture problem may be, or whatever the whims of his teacher may be, he can be sure of contact with a wide variety of treatment. Practically all of the accepted and commonly used methods are described in detail, and many other methods are outlined and considered. However, treatment is not discussed to the exclusion of other factors important in this branch of surgery. The practitioner will be equally impressed with the book because it is handled in such a way as to make immediately available the ideas and suggestions of the authors. Properly, they do not stress elaborate equipment but give the impression that common sense and a few fundamental principles, together with the ordinary working appliances, constitute good treatment.

At the beginning of each chapter is an impressive review of the essential points of the surgical anatomy of the part involved. Here also is given a method of examination by means of which a diagnosis is made. X-ray films are illustrated and interpreted, and in those instances in which the technique of obtaining proper x-ray films is important, a method of doing so is suggested.

In the opening chapter entitled "General Considerations" one finds a discussion of modern methods and the use of modern equipment in the treatment of fractures. Details for the construction of various types of overhead frames, suspension apparatus and the like are given; also there is given an outline of the type of splints and equipment which should be kept in all first aid offices and in hospitals and fracture operating rooms. For those who prefer to make their own plaster bandages, instructions are given for their preparation and use. One chapter is devoted to a condensation of the literature on the subject of healing of bone and the factors which tend to cause delayed union and non-union. Here students will find excellent microscopic illustrations of the healing process in bone. However, Figures 40 and 41 are not particularly good illustrations of the subject of non-union.

The remainder of the book is divided into chapters, each dealing with injuries to different areas. The late Dr. Dowman has contributed a very readable and instructive chapter on skull fractures and brain trauma. This chapter is remarkably succinct and will be appreciated by those who like to take their surgery with a generous dash of palatable physiology. In this chapter is a useful outline for examination when one is confronted with a case of head injury, whether or not the patient is able to co-operate.

Dr. Brown's chapter on fractures of the jaw and related bones of the face is most complete. Such work, of course, is highly specialized, but the author generously discusses the problems which arise in this field from the standpoint of the general practitioner who first sees the patient, as well as from that of the plastic or oral surgeon.

The chapter on injuries in the region of the hip is long and practically all inclusive. The controversial point regarding the treatment of fractures of the neck of the femur are handled tactfully and completely, and the authors apparently have no bias in this respect and no axes to grind.

About 95 pages are devoted to injuries of the bony and nervous elements of the spine. This section is exceptionally well done, and the anatomic considerations and the lengthy consideration of the important subject of low back pain from the industrial and compensation standpoint will be valuable to the reader. This chapter is profusely illustrated with photographs and x-ray pictures, and in it one can obtain information that concerns the reduction of a fractured spine with the latest type of fracture table, and also with such tables as one might find in a farmhouse kitchen. The currently popular nucleus pulposus rupture is given space but is not discussed at great length.

This book is recommended to those who wish to keep abreast of modern traumatic surgery.

JAMES K. STACK.

THE textbook entitled *A Method of Anatomy*,[2] according to the publishers, presents a "superexcellent" new method of teaching anatomy. Its method assuredly does involve "certain departures from tradition"; but an interesting, novel approach to a science is not of necessity eminently good; and the traditional ofttimes represents a discipline that should be perpetuated.

The volume does not purport to be a dissector's guide, yet some directions for procedure are introduced; but these are sketchy and do not carry the student logically through regional strata; nor do the illustrations serially portray progressively deeper levels.

It is most definitely not usable as an atlas, since the illustrations are completely or partially diagrammatic in character; they are made, throughout, from line drawings. In the entire volume there is not a single wholly accurate figure of human gross structure; the medium employed renders it impossible to portray human tissue in natural form. Were the ingenious diagrams placed in association with drawings of the type employed in the standard atlases, they would be valuable indeed; they have, however, been lifted from the category of the subordinate to that of the principal. In many instances, abbrevia-

[1] THE MANAGEMENT OF FRACTURES, DISLOCATIONS, AND SPRAINS. By John Albert Key, B.S., M.D., and H. Earle Conwell, M.D., F.A.C.S. 2d ed. St. Louis: The C. V. Mosby Co., 1937.

[2] A METHOD OF ANATOMY; DESCRIPTIVE AND DEDUCTIVE. By J. C. Boileau Grant, M.C., M.B., Ch.B., F.R.C.S. (Edin.). Baltimore: William Wood & Co., 1937.

tions are used without key; some of the abbreviations are unfortunately cryptic; frequently none would be needed were the lettering less obtrusively large.

The volume cannot be employed to replace the standard textbooks, since systematic accounts are wanting, the regional approach requiring the author to separate his discussion of a given structure into portions, to spread these widely through a chapter; the common typographical aids are lacking.

But this book, which is a manual of regional anatomy replete with concepts, is unique in its attempt to teach anatomy in such a way that underlying principles, rather than mere facts, are made its chief content. The reader is surfeited with *rationale*, not left free to concoct his ideas from ingredients furnished by book and dissection. Admittedly, no student could arrive at so many valuable notions as does Professor Grant, whose years of teaching have been rich and active; his experience has allowed him to furnish some of the most ingenious bits of description yet encountered in anatomical writing. For example, muscles are descriptively associated with the execution of certain common tasks, as the biceps is to the act of turning a screw driver; the peritoneal cavity is likened to an enormous closed bursa; the genito-urinary apparatus, with adnexa, is compared with the bilateral immobile leaves of a book, the gastro-intestinal tract (with mesentery) to a mobile leaf in midplane; femoral sheath, and pelvic diaphragm, are treated with equal cleverness. But in the commendable desire to simplify, many important details of anatomy are omitted; the abdominal layers are inadequately described; important visceral variations are not mentioned; no discussion is given of the intimate manner in which genito-urinary, parietal, diaphragmatic structures are brought into relationship through the vascular system; the description of the region of femoral hernia presents only the old-time opinions; the sling-like character of the pelvic diaphragm is exaggerated. Simplification becomes so demanding that what remains of fundamental description is actually quite "traditional."

Professor Grant's provocative volume can scarcely be regarded as one which will replace any regular part of the student's anatomical library. It could, most profitably, be added to such a library. For the graduate student it would be an elixir; the surgical anatomist could profitably employ it as a source book for lecture material; it is a "super-excellent" hornbook for the young teacher. BARRY ANSON.

THE theoretical principles of roentgen therapy set forth in the work edited by Pohle[1] constitute a document of great value for everyone concerned in the therapeutic application of the roentgen rays. The statements relating to the physics of the roentgen rays, dosimetry, radiobiology, and radiopathology are not likely to be essentially changed for many years to come. The chapters on radiotherapy apparatus and protection from the roentgen rays may undergo some modification with the advance of the science. As Chamberlain states in the foreword, the content of this present volume is factual and constitutes a solid foundation on which to build new knowledge of radiotherapy.

The five contributors have collaborated with the editor to produce this concise and meaty test. It is really the first publication in English concerning the modern trends in radiotherapy, and radiologists who undertake therapy can hardly do without it.

JAMES T. CASE.

THE subject of hemorrhoids is completely covered by Pruitt[2] in his 170 page monograph. It is written in a concise, direct, and readable manner. The 73 illustrations and photographs, many of which are colored, enhance the usefulness of the book. Inasmuch as a considerable portion of the subject matter is basic in character, it is infinitely more suitable to the needs of the general practitioner and general surgeon than to the rectal specialist.

Chapters are devoted to embryology, surgical anatomy, physiology, methods of examination, the most suitable instruments to use for this type of work, and the various types of anesthesia applicable to the treatment of hemorrhoids. Diagnosis and differential diagnosis are followed by a discussion of the various forms of treatment. Operative and non-operative methods are discussed with a pictorial description of the various accepted techniques.

In discussing the non-operative methods of treatment, the author advocates treating all the internal hemorrhoids at one visit. This technique may be a safe and successful procedure in the hands of a proctologist, but is apt to carry an unnecessary risk when followed by the occasional rectal therapist.

Too much emphasis is placed on the practice and value of sphincter divulsion before hemorrhoidectomy. Barring the exceptional case, good regional anesthesia will make this procedure unnecessary for sphincter relaxation and for the exposure of the hemorrhoids.

The chapter on choice and evaluation of treatment is exceptionally valuable.

THOMAS JAMES MERAR.

THIS third edition of Crotti's monumental tome[3] contains several hundred pages of additional material. The field has been broadened to include hypoparathyroidism and hyperparathyroidism in addition to all phases of thyroid physiology and pathology. The discussion of the thymus is complete as usual and the author's interesting studies of the relation of fungi to goiter and thyroid disease are

[1] THEORETICAL PRINCIPLES OF ROENTGEN THERAPY. Edited by Ernst A. Pohle, M.D., Ph.D., F.A.C.R. Foreword by W. Edward Chamberlain, B.S., M.D., F.A.C.R. Philadelphia: Lea & Febiger, 1938.

[2] HEMORRHOIDS. By Marion C. Pruitt, M.D., L.R.C.P., S. (Ed.), F.R.C.S. (Ed.), F.A.C.S. St. Louis: The C. V. Mosby Co., 1938.

[3] DISEASES OF THE THYROID, PARATHYROID AND THYMUS. By André Crotti, M.D., F.A.C.S., LL.D., R.I.C.S., 3d ed. Philadelphia: Lea & Febiger, 1938.

thoroughly presented with numerous microphotographs of the organisms found.

A great variety of interesting problems is taken up in this beautiful volume. The discussion is always accompanied by continual reference to the literature. Valuable reviews of periods of thyroid study of historical significance are given, such as the Kocher-Reverdin controversy in 1882–1883. An extensive bibliography and thorough index are appended. We can be grateful for the reappearance of Doctor Crotti's work in this new edition.

PAUL STARR.

THE purpose of *Neuro-ophthalmology*[1] as prefaced by the author is to supply a book of moderate proportions which would supply an answer for questions regarding those subjects which form a connecting link between ophthalmology and neurology. For this purpose he has written a volume of 526 pages, well illustrated, including colored plates with a bibliography, though not extensive, furnishing a basis for further reading on a subject in question.

The subject matter discussed includes chapters on the equipment necessary for the examination from the neurological point of view of the eye, the pupil and its reactions, the muscles and nerves of the eye and its adnexa; papilledema; optic atrophy; visual tracts and cortical representation of vision; interpretation and localization of lesions in the visual pathway as shown by the perimeter; the macula; localizing value of ocular symptoms in the diseases of the brain, abnormalities, congenital and degenerative; subarachnoid hemorrhage; tumors of the optic nerve; the region of the optic chiasm and pituitary body; ocular manifestations in diseases of the nervous system; affections of the vegetative nervous system; ocular manifestations of head injuries; poisons which affect vision; headache; and amaurosis.

Regarding the recommendations and criticism of this book, considering the author's purpose, it seems definite that the volume fills a need in ophthalmic literature. It might be stressed that the subject matter is mainly clinical and presented apparently from that point of view. It is interesting and easily read, following somewhat a lecture style with occasional reference to cases of the author, and an occasional diversion from the trend of the subject matter presented. One might be disappointed from the title in the small amount of actual neuroanatomy and neurophysiology, or physiopathology presented but apparently this was not the purpose of the author. There are clinical statements with which one might not well agree, yet as a whole, there has been presented a wealth of clinical material in a readily accessible form, and the book is to be recommended as a link between ophthalmology and clinical neurology.

WM. H. DROEGEMUELLER.

[1] NEURO-OPHTHALMOLOGY. By R. Lindsay Rea, B.Sc., M.D., M.Ch., F.R.C.S. St. Louis: The C. V. Mosby Co., 1938.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

THE 1938 YEAR BOOK OF PHYSICAL THERAPY. Edited by Richard Kovács, M.D. Chicago: The Year Book Publishers, 1938.

SURGICAL PATHOLOGY. By William Boyd, M.D., LL.D., M.R.C.P.(Ed.,) F.R.C.P., F.R.C.S. 4th rev. ed. Philadelphia and London: W. B. Saunders Co., 1938.

THE PRINCIPLES AND PRACTICE OF OBSTETRICS. By Joseph B. DeLee, A.M., M.D. 7th ed. Philadelphia and London: W. B. Saunders Co., 1938.

L'IPERTROFIA DELLA PROSTATA. By Prof. Dr. N. Carraro and Dr. I. Wugmeister. Preface by Prof. G. Marion. Milan, Italy: Edizione Libreria Bocca, 1938.

CLINICAL ROENTGENOLOGY OF THE DIGESTIVE TRACT. By Maurice Feldman, M.D. Baltimore: William Wood & Co., 1938.

ADVENTURES IN RESPIRATION; MODES OF ASPHYXIATION AND METHODS OF RESUSCITATION. By Yandell Henderson. Baltimore: The Williams & Wilkins Co., 1938.

THE ROCKEFELLER FOUNDATION. International Health Division Annual Report 1937. New York, 1938.

THE HEALING KNIFE; A SURGEON'S DESTINY. By George Sava. New York: Harcourt, Brace & Co., 1938.

PLASTIC SURGERY. By Arthur Joseph Barsky, M.D., D.D.S. Philadelphia and London: W. B. Saunders Co., 1938.

A HISTORICAL CHRONOLOGY OF TUBERCULOSIS. By Richard M. Burke, M.D. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1938.

A MANUAL OF REPARATIVE PLASTIC SURGERY. By J. Eastman Sheehan, M.D., F.A.C.S. New York and London: Paul B. Hoeber, Inc., 1938.

ESSENTIALS OF PATHOLOGY. By Lawrence W. Smith, M.D., and Edwin S. Gault, M.D. With a foreword by James Ewing, M.D. New York and London: D. Appleton-Century Co., Inc., 1938.

CRANIO-CEREBRAL INJURIES; THEIR DIAGNOSIS AND TREATMENT. By Donald Munro, A.B., M.D., F.A.C.S. London, New York, Toronto: Oxford University Press, 1938.

THE 1938 YEAR BOOK OF RADIOLOGY. DIAGNOSIS. Edited by Charles A. Waters, M.D., and Whitmer B. Firor, M.D. THERAPEUTICS. Edited by Ira I. Kaplan, B.Sc., M.D. Chicago: The Year Book Publishers, Inc., 1938.

THE HUMAN BODY IN PICTURES. A visual Text of Anatomy, Physiology and Embryology. By Jacob Sarnoff, M.D. With Foreword by John Osborn Polak, M.D. Brooklyn, N.Y.: Physicians and Surgeons Book Co., 1927, 1938.

DISEASES OF THE EAR, NOSE AND THROAT. By Francis L. Lederer, B.Sc., M.D., F.A.C.S. Philadelphia: F. A. Davis Co., 1938.

MEDICINE IN THE OUTPATIENT DEPARTMENT; AN INTRODUCTORY HANDBOOK. By Winthrop Wetherbee, Jr., M.D. With a foreword by George R. Minot, M.D., S.D., F.R.C.P.

(Edin. and Lond.), F.A.C.P. New York and London: Paul B. Hoeber, Inc., 1938.

THE HOME BOOK OF MEDICINE. By David Polowe, M.D. New York: Greenberg, Publisher, Inc., 1938.

UROLOGY. By Daniel N. Eisendrath, M.D., and Harry C. Rolnick, M.D. 4th rev. ed. Philadelphia, Montreal, London: J. B. Lippincott Co., 1938.

SPINAL ANESTHESIA. By Louis H. Maxson, A.B., M.D. Foreword by W. Wayne Babcock, M.D., LL.D., F.A.C.S. Philadelphia, London, New York, and Montreal: J. B. Lippincott Co., 1938.

HUMAN PATHOLOGY; A TEXTBOOK. By Howard T. Karsner, M.D. With an introduction by Simon Flexner, M.D. 5th rev. ed. Philadelphia and London: J. B. Lippincott Co., 1938.

A TEXTBOOK OF MEDICAL BACTERIOLOGY. By David L. Belding, M.D., and Alice T. Marston, Ph.D., et al. New York and London: D. Appleton-Century Co., Inc., 1938.

INTERNS HANDBOOK; A GUIDE, ESPECIALLY IN EMERGENCIES, FOR THE INTERN AND THE PHYSICIAN IN GENERAL PRACTICE. By Members of the Faculty of the College of Medicine, Syracuse University. Under the direction of M. S. Dooley, A.B., M.D. 2d rev. ed. Philadelphia, London, Montreal: J. B. Lippincott Co., 1938.

THE PRACTICE OF MEDICINE. By Jonathan Campbell Meakins, M.D., LL.D. 2d ed. St. Louis: The C. V. Mosby Co., 1938.

THE FUNDAMENTALS OF INTERNAL MEDICINE. By Wallace Mason Yater, A.B., M.D., M.S. New York and London: D. Appleton-Century Co. Inc., 1938.

THE RELATION BETWEEN INJURY AND DISEASE. By Jewett V. Reed, B.S., M.D., F.A.C.S., Charles P. Emerson, A.B., M.D., D.Sc. Collaborating E. B. Mumford, B.S., M.D., F.A.C.S. Indianapolis: The Bobbs-Merrill Co., 1938.

DISEASES OF WOMEN. By ten teachers. Under the direction of Clifford White, M.D., B.S.(Lond.), F.R.C.P. (Lond.), F.R.C.S.(Eng.), F.C.O.G. Edited by Sir Comyns Berkeley, Clifford White, and Frank Cook. 6th ed. Baltimore: William Wood & Co., 1938.

CORRESPONDENCE

FRACTURE OF THE FEMORAL NECK; A RAPID AND ACCURATE METHOD OF INTERNAL FIXATION USING A FLANGED METALLIC NAIL—A CORRECTION

To the Editor: In my article entitled "Fracture of the Femoral Neck, a Rapid and Accurate Method of Internal Fixation using a Flanged Metallic Nail," the third paragraph, first sentence, should read as follows:

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EMMETT A. DOOLEY.

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